I. *Heliometer-Determinations of Stellar Parallax in the Southern Hemisphere.*

By David Gill, LL.D., F.R.S., and W. L. Elkin, Ph.D.

[Received and read Jan. 11, 1884.]

Preface.

On my appointment to the post of H.M. Astronomer at the Cape of Good Hope, I became anxious to possess instrumental means for investigating some of the more interesting problems which the Southern Heavens offer. I knew that means, such as I required, were not immediately available, and that some time must elapse before they could be adequately supplied. I was, therefore, fortunate in acquiring by private purchase the Heliometer with which, in conjunction with Lord Lindsay's expedition, I had observed the opposition of *Juno* at Mauritius in 1874,* and which I had afterwards employed (by the kindness of Lord Lindsay) in the Society's Expedition to Ascension in 1877.†

A full description of the instrument is given in Vol. II. of the "*Dun Echt Publications.*"

The equatorial mounting of the instrument I could not obtain, as it formed the stand of one of the telescopes in use at Dun Echt. I therefore ordered a new equatorial stand for the Heliometer-tube and cradle from Mr. Grubb, and took advantage of the opportunity thus offered to have some alterations made on the instrument, which previous experience had proved to be desirable. These referred chiefly to slow motion of the tube in position angle. In the original instrument the quick motion in position

* *Dun Echt Publications*, vol. ii. † *Mem. R.A.S.* vol. xlvi. pp. 1–172.

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angle was accomplished by turning a rod which carried a pinion which acted on a wheel of which the Heliometer-tube formed the axis. Slow motion was given by merely rotating this rod very slowly by means of a toothed wheel acted on by a tangent screw, but the effect was to create a certain amount of torsion of the rod before any rotation of the tube took place, so that there was wanting that immediate and precise response to the observer's action which is essential for easy and exact measurement. I therefore planned the following arrangement. At the end of the cradle, next to the observer, there is smoothly fitted on the tube (or rather on one of the collars attached to the tube) a ratched wheel with square-cut teeth. This wheel is so fitted as to turn smoothly on the collar, but when the observer so desires, it can be clamped firmly to the tube by a handle coming down to the eye-end. A steel screw with a square-cut thread (such as GRUBB uses for the driving screws of his Equatorials) acts on the teeth of this wheel, whilst the pivots of this screw rest in bushes in a frame attached to the cradle. The screw is turned by bevel wheels, acted on by a handle coming down to the eye-end.

When the observer turns the handle, the wheel slowly rotates ; and, if the tube is clamped to the wheel, a smooth easy rotation is communicated to the tube. This slow motion, as well as the equatorial mounting, and the driving clock, have been admirably constructed by Mr. GRUBB, and the instrument is in every respect efficient, stable, and convenient.

During a visit to some of the principal European Observatories, before my departure for the Cape, I met Mr. W. L. ELKIN, a student under Prof. WINNECKE, who was then engaged in preparing his "*Inaugural Dissertation*" for the degree of Doctor of Philosophy at the University of Strasburg. The subject he had selected was the Orbit and Parallax of α *Centauri*, and he applied to me for any observations of α *Centauri* as a double star, or any meridian observations of α and β *Centauri* which I might find on the records of the Cape Observatory, and which were still unpublished.* In course of conversation I informed Mr. ELKIN of my purchase of the Heliometer, and of

* These observations I supplied to him soon after my arrival at the Cape, and they are incorporated in his Dissertation *Ueber die Parallaxe von α Centauri.* Karlsruhe, 1880.

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the purposes to which I intended to apply it. He expressed much interest in my programme, and his keen desire to take part in such work.

It was finally arranged that, on the completion of his curriculum, and after the arrival of the Heliometer, Dr. ELKIN should come to the Cape and share my labours.

The Heliometer reached the Cape in the end of December 1880, and I proceeded at once to erect it in an old Observatory, which had been built by Sir THOMAS MACLEAR, in 1847, to cover a small telescope by Dollond. This Observatory is described by him (*Mem. R.A.S.* vol. xx. pp. 31–34). I had duly completed the necessary alterations of the building and the adjustments of the instrument when Dr. ELKIN arrived at the Cape on Jan. 31, 1881, and the following month was spent in preliminary experiments, in the selection of stars of comparison, and in the preparation of a programme.

This settled, I was on the point of leaving for Durban and Aden, to carry out the longitude operations connecting these places with the Cape, when I was suddenly recalled to England on urgent private affairs. I made new arrangements for the longitude work, so that when I returned to the Cape (June 30, 1881) I was enabled to take up the programme of the Heliometer observations at an earlier date than I originally intended. Dr. ELKIN occupied my house in my absence, and remained as my guest, and as a member of my family circle, till the completion of our programme. He sailed from the Cape on May 16, 1883. His work from first to last has been a labour of love.

DAVID GILL.

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INTRODUCTION.

THE general idea which guided the preparation of our programme was to make such a contribution to existing knowledge of the parallax of Southern Stars as we could accomplish in a series of observations originally calculated to extend over a period of eighteen months.

We also resolved that several of the parallaxes determined should be investigated independently by both observers, and with different comparison stars, in order to obtain some test of the general accuracy of our conclusions. After much consideration and trial the following stars were finally selected :

For observation by GILL and ELKIN	... ...	*α Centauri, Sirius, ε Indi.*
„ GILL only	... ...	*Lacaille 9352, o_2 Eridani, β Centauri.*
„ ELKIN only	... ...	*ζ Tucanae, e Eridani, Canopus.*

It was originally intended to include also the stars *Fomalhaut* and *Piazzi XIV.* 212, but it was found on trial that, without them, we had undertaken the maximum of work it was possible to sustain.

The considerations which have led us to the selection of these objects and their comparison stars are summarised in the following notes.

α Centauri.

It requires no apology for devoting a large share of our labour to the investigation of the parallax of this star. It is the most remarkable and conspicuous double star in the heavens ; it has long been considered our nearest neighbour amongst the stars, and to the Cape astronomer it possesses a peculiar historical interest, from the fact that its observation with the Cape Mural Circle, by HENDERSON, first afforded very strong presumptive evidence of the measurable parallax of any fixed star. HENDERSON'S results, though strongly confirmed by those of MACLEAR, were still liable to a certain amount of doubt, and astronomers have long desired a determination of the parallax of *α Centauri* by differential methods. We had hoped to find in the neigh-

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bourhood of α *Centauri* a considerable choice of comparison stars, but on first examination it seemed that there were only two available pairs bright enough for measurement, and which, at the same time, sufficiently realised the other desirable conditions.

The first of these is composed of the stars α and β (Plate I., fig. 1) of mag. 7·0 and $7\frac{1}{4}$ respectively. Both stars are sufficiently bright for easy measurement; their position angles relative to α *Centauri* differ almost exactly 180°, the difference of their distances from α *Centauri* is little more than one-tenth of the interval between the comparison stars, and, as will be seen by the dotted line which represents the parallactic ellipse, they are favourably situated as to parallax factor in the measurement of distance. The second pair is composed of the stars *a* and *b*, of 6·9 and 7·5 magnitude respectively. Besides the greater inequality of magnitude, the positions of the stars are less favourable in respect of symmetry and parallax factor than the pair α β. The pair α β was assigned to GILL, the pair *a b* to ELKIN.

But besides the above-mentioned considerations, there is a further condition which limited the selection of comparison stars, viz.—the position angle of the components of α *Centauri*. This angle (about 195° during the period of our work) differs sufficiently from the position angle of the stars α β (146°) to create no confusion of the image of the comparison star with that of α_1 *Centauri*, when the former is made to pass and to repass through the image of α_2 *Centauri* in a direction at right angles to the line of measurement, as must be done in Heliometer measures. The pair *a b* is still more free from this difficulty, for the component stars of α *Centauri* are nearly in the line joining *a b*. But when we attempted the measurement of some faint comparison stars in position angle about 90°, it appeared certain that no satisfactory results could be got, because the image of the comparison star became confused with that of α_1 *Centauri* so soon as it had been brought through the image of α_2 *Centauri*, and thus the observer could not form an accurate judgment of the symmetrical passing and repassing of the discs over each other.

When GILL returned from England, in June 1881, he brought out a supply of wire gauze of different kinds, by the aid of which ELKIN found it possible to construct a screen, such that the magnitude of the star α_2 was reduced to magnitude $8\frac{1}{4}$, whilst the star α_1 was practically obliterated.*

* From measures with a Pickering-photometer we found the difference of the magnitudes

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Search was accordingly made, and from the numerous stars about 8th magnitude two pairs were finally selected near the parallel of α *Centauri* shown as a' b' and a' β' in Plate I., fig. 1. Of these the closer and more symmetrical pair a' b' was assigned to ELKIN, and the pair a' β' was taken up by GILL.

It was not without some slight misgiving that we finally resolved to employ these stars—fainter than $7\frac{1}{2}$ magnitude. With stars of the latter magnitude, or brighter, our Heliometer (4 inches aperture) shows very sharply the elongation of the disc at right angles to the line of measurement. The axis of greatest elongation of each image affords thus two imaginary lines, and the coincidence of these lines marks very sharply the symmetrical crossing of discs in the act of measurement. But with the fainter stars this aid in the estimation of bisection is not available, and the observer is compelled to resort to the less objective methods afterwards described.

Sirius.

As the brightest star in the heavens, and situated too far South in Declination for successful observation at the great Northern Observatories, *Sirius* presents an object the importance of the determination of whose parallax requires almost less explanation than that of α *Centauri*. Indeed, the elder STRUVE once suggested the erection of a Prime-Vertical Transit, like his celebrated Pulkowa instrument, at the Island of St. Helena, for this purpose only.

A search for suitable comparison stars resulted in the selection of the following pairs (see Plate I., fig. 2), viz. :—

a and b of $7\frac{3}{4}$ and 8th magnitude respectively, and
α and β each of 7th magnitude.

The first of these pairs is very symmetrically situated with respect to *Sirius*; and, as will be evident from the dotted line which indicates the parallactic ellipse, it affords a large factor of parallax for measures of distance. These comparison stars, however, are, from previously-mentioned considerations, both rather fainter than is desirable, and they are also somewhat unequal in

$a_2 - a_1$ to be $1\frac{1}{4}$ magnitudes. By the screen in question the image of a_1 was therefore reduced to a star of $9\frac{1}{2}$ magnitude, and it was practically invisible in the slightly illuminated field which we employed.

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magnitude. The pair $\alpha\ \beta$ affords a somewhat smaller parallax factor; and, though both stars are very nearly equal in distance from *Sirius*, they are not very symmetrically placed in position angle. There is a star, γ (Plate I., fig. 2), which is situated so as to pair very symmetrically with β, but as γ is considerably fainter than β, whilst α and β are identical in magnitude, it was decided to employ the stars α and β in preference to β and γ.

There are other available pairs in the neighbourhood of *Sirius*, but partly because these pairs (nearly at right angles to each other) afford means, in the future, for an accurate determination of the periodic motion of *Sirius* from measures of distance only, and partly because no two better pairs could be found, the pair $\alpha\ \beta$ was selected by GILL, and the pair *a b* by ELKIN.

ϵ *Indi.*

Until the discovery by GOULD of the proper motion of the star *Lacaille* 9352, ϵ *Indi* was the star of largest known proper motion in the Southern Hemisphere. The star itself is estimated by GOULD of 5·2 magnitude, and we have employed the following pairs of comparison stars (see Plate I., fig. 3), viz. :—

a and *b* of 7 and $7\frac{1}{4}$ magnitude respectively.
α and β of $7\frac{1}{4}$ and $7\frac{3}{4}$ „ „

The former pair, which, as will be evident from the figure, is much the more symmetrical, and has the larger parallax factor, was taken up by ELKIN; the latter pair was taken up by GILL, as he had observed it at the Island of Ascension in 1877.

Of the six remaining stars four were selected on account of their large proper motion, and two for reasons detailed in the sections devoted to them.

Methods of Observation and Reduction.

The observations, on which the following researches depend, consist of measures of the distance of the principal star from two comparison stars situated on opposite sides of it. It is an essential feature of the method that the observations of both distances are arranged so as to be practically simultaneous, in order that the *instantaneous scale-value* may be the same

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for the measures of both pairs. A "*measure*" may be defined as two bisections (or "pointings") made in reversed positions of the segments, so as to eliminate constant index error. A "*complete set*" may be defined as four *measures* of the distance of each of two opposite comparison stars from the principal star.

The arrangement of the observations of a *complete set* will be evident from the following table: *

Bisection.	Comparison Star Observed.	Reading of Scale A.	Direction of Final Motion of Distance handle.	Measure.
1	α	greater	right	α
2	α	smaller	left	
3	β	smaller	right	β
4	β	greater	left	
Tube rotated 180° in its cradle.				
5	β	greater	right	β
6	β	smaller	left	
7	α	smaller	right	α
8	α	greater	left	
9	α	greater	right	α
10	α	smaller	left	
11	β	smaller	right	β
12	β	greater	left	
Tube rotated 180° in its cradle, that is, turned back to its original position.				
13	β	greater	right	β
14	β	smaller	left	
15	α	smaller	right	α
16	α	greater	left	

The measures are thus arranged in the order most favourable for eliminating possible progressive change of index error or of scale value. It has

* A "*half set*," consisting of the first eight bisections of a *complete set*, also constitutes a symmetrical observation, and as such is utilized (with half weight) when, from interruption by cloud or other causes, it has not been possible to obtain a *complete set*.

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been usual to begin our sets of observations alternately with star α and star β on alternate days.

It is worthy of note that, by flexure of the Heliometer-tube and microscope, the optical axis of the reading microscope intersects a somewhat different part of the scales when the Heliometer-tube is reversed in position angle; and by "loss of time" in the teeth of the sector and the joints of the rods which move the segments, parts of the scale, different by about $\frac{1}{4}$ of a revolution of the micrometer screw, come opposite the axis of the microscope, when the last motion of the distance-measuring handle is made in reversed directions. Thus, in none of the eight bisections of each star are the micrometer readings the same; and, as two divisions on each scale are read, the result of each complete set depends on 64 readings at 64 different parts of the screw. We might on this account have probably safely neglected the application of corrections for error of the screw, but we have preferred a more rigid course, and the errors of the screw have been investigated independently by both observers in 1881 with great care. The following expression represents, in the usual notation, the corrections we have applied to the screw readings :—

$$\overset{r}{\cdot 00021}\cos u - \overset{r}{\cdot 00165}\sin u - \overset{r}{\cdot 00017}\cos 2u + \overset{r}{\cdot 00043}\sin 2u + \overset{r}{\cdot 00097}\, n - \overset{r}{\cdot 00024}\, n^2$$

where n is the number of revolutions from 0^r.

This expression represents the results of both observers with extreme accuracy; the largest residual amounts to $0^r{\cdot}0010$.

The errors of the screw were reinvestigated by Dr. Elkin in 1883 with precisely like results, so that no change in the error of the screw occurred during the progress of the measures.

The runs have been deduced from the observations of each set, and applied to all the readings of that set, and the same divisions have been used throughout all the observations of the same star.

The absolute scale value has not been employed in the deduction of any of our results. That value varies with the temperature of the scale and object-glass, and with the adjustment of the focus, and is besides inseparable from the refraction. It is practically impossible to determine accurately the temperature of the object-glass and of the scale, and to preserve the setting of the focus of the eyepiece (combined with the eye) in rigid relation to the

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focal plane. But we can assume that the distance between our comparison stars is a constant quantity (after correction for refraction, aberration, &c.), or a quantity varying proportionally with the time. For focal adjustment we have contented ourselves with setting the focussing scale always at the same reading (9·50), with the eyepiece pushed home; this reading is always practically near the truth, for the change of focal length of the object-glass by temperature is nearly the same as that of the brass tube. The temperature of the air at the Cape changes somewhat rapidly during the two hours preceding sunset, but from about an hour after sunset it remains usually very constant during the night. It has been our practice to open the dome soon after sunset, and to allow as long an interval as possible to elapse for equalisation of the temperature of the instrument with that of the outer air before observations are commenced. The Barometer and external Thermometer have, as a rule, been read immediately before and after each set of observations.

The corrections for refraction have been very rigorously computed. The special tables employed will be published with the details of the observations in the annual volumes of the publications of the Royal Observatory, Cape of Good Hope.

It is then clearly to be understood that in all the reductions which follow, no reliance whatever is placed on absolute measures—all the results will be made to depend on the *difference* of two nearly equal and opposite distances, the scale value for this difference being deduced from the observed *sum* of the two distances.*

We believe that with the above-described precautions all *instrumental errors* have been entirely eliminated, and that the only systematic errors which can affect our results are *personal errors*, such as may arise from a change in the observer's mode or habit of bisection. Such change may take place gradually, and may be treated as a term depending on the time, or it may depend on the direction of measurement with respect to the vertical, *i.e.* on the angle $p-q$,—where p is the position angle and q the parallactic angle.

To eliminate such errors, GILL, in observing *Mars* at Ascension, used a reversing prism placed between the eyepiece and the observer's eye. By

* There is one exception to this rule in the case of β *Centauri*, but the principle is preserved in other ways.

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simply rotating this prism the apparent direction of measurement could be made the same for all values of $p-q$, and the systematic errors, due to want of symmetry in one of the objects or to astigmatism of the observer's eye, can be eliminated by rotating the prism 90° between each measure.

But in observing well defined star-discs we did not expect to find any such personal error. If there are three stars, *a c b*, in a straight line, of which the middle star *c* is nearly equally distant from *a* and *b*, and if the three stars are of precisely equal brilliancy and similar colour, then the measured value of (distance *a c*—distance *b c*) must be entirely independent of any systematic error depending on *p*—*q*, for any personal error of the kind must affect both measures of distance equally, and must therefore disappear from the *difference*. But if *c* is markedly different from *a* and *b*, and especially if *c* is a double star, or very different in magnitude from *a* and *b* (particularly when *a* and *b* or *c* are near the limit of observable magnitude), *then* it is not impossible that such personal errors may exist, and that they can only be eliminated by the use of a reversing prism or by actual determination.

We originally intended to employ a reversing prism, but the one used at Ascension was unfortunately lost, and the two prisms made to supply its place were by no means satisfactory. Partly because the latter prisms did not give very sharp images, and, besides, absorbed a considerable amount of light, and partly because we did not believe in the existence of personal error depending on *p*—*q* in the case of star discs, we resolved not to delay the observations by waiting till a satisfactory prism could be procured.

The observations were, therefore, commenced without the prism, and had to be so completed for sake of uniformity. We may here anticipate the result of after-discussion by stating that *personal error*, in cases such as those above described, has been found to exist in a very marked degree, and its elimination has cost much labour that we should probably have been spared if the prism had been employed.

The highest eyepiece provided with the instrument (power 175) has been used throughout the observations.

The results of all the complete sets or half-sets observed in connection with each investigation are quoted, whatever the atmospheric conditions in which they were made.

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The atmospheric conditions of quality of image and steadiness are defined by the following scale.

1	...	...	...	...	Excellent
1–2	...	...	...	...	Good
2	...	...	...	...	Fair
2–3	...	...	...	...	Middling
3	...	...	...	...	Poor
3–4	...	...	...	...	Bad
4	...	...	...	...	Impossible

Thus I = 1–2, S = 3—would mean that the images were "good" (or "sharp"), but the steadiness "poor" (or considerable motion, so as to make the resulting bisection "poor" or somewhat uncertain). Observations made in conditions of image and steadiness worse than 3, and steadiness worse than 3–4, have not been employed in the reductions.

In computing the effect of proper motion and aberration and in the deduction of the parallaxes a semi-revolution (R) of the micrometer screw has been taken.

$$R = 12''.865.$$

From this point our work has been carried out independently, each observer being responsible for the reduction and discussion of his own observations. This arrangement (necessitated by the fact that during the preparation of these Memoirs we were resident in different hemispheres) has led to some want of uniformity of notation, and to other trifling discrepancies—for example, the significations of y and z have been inadvertently exchanged in our respective papers. But the memoirs of each author are mutually connected, and in a final section we summarise our results, and endeavour to draw some general conclusions from our experience.

D. G.
W. L. E.

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§ 1. *Parallax of α Centauri.* GILL.

The first series of observations which I made to determine the parallax of *α Centauri* consists of measures of the angular distance of α_2 *Centauri* from the comparison stars *a* and *β* mentioned in the Introduction.

The following, so far as I know, are all the existing Meridian observations of these stars; the Cordoba results have been kindly communicated by Dr. GOULD.

Authority.	Epoch.	1882·0.		No. of Observations.
		α	δ	
		Star α.		
Lacaille 5973	1750	h m s 14 26 30·35	° ′ ″ −59 29 42·2	1
Brisbane 4953	1825	30·35*	29 36·6	3
Taylor 6783	1835	29·11*	29 41·4*	3
Stone 7923	1875·5	29·40	29 42·0	3
Gould	1875·5	29·57	29 40·5	4
Cape	1883·1	29·30	29 41·6	12
		Star β.		
Gould, Cordoba Zones		14 35 51·26	−61 1 4·5	1
Gould	1880·6	51·11	9·0	1
Cape	1883·0	51·13	7·8	12

* With corrections as in ELKIN's paper, § 3, p. 54.

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The place of α_2 *Centauri* for 1882·0 according to ELKIN* is

α	δ
h m s	° ′ ″
14 31 35·77	−60 20 46·7,

hence the relative positions of the comparison stars to α_2 *Centauri* are, from the Cape co-ordinates of the comparison stars,

Star.	Magnitude	Position Angle.	Distance.
		°	″ R
a	7	323·07	3835·6=298·1
β	7¼	142·24	3063·0=238·1
		Diff. 180·83	60·0

The proper motions of the comparison stars cannot be considered known from the above data, we can only suppose them to be very small.

The motion of α_2 *Centauri* has been deduced by ELKIN as follows :

The proper motion of the centre of gravity and the ratio of masses of α_1 and α_2 *Centauri* have been taken as in his Dissertation above referred to, viz. :

$$\Delta\alpha \cos\delta = -3''\cdot593$$
$$\Delta\delta = +0''\cdot747$$
$$m_1 = m_2,$$

and these data still fairly represent the Meridian observations up to 1883.

The relative positions of the two components are taken from the following formulæ :

For $\alpha_2-\alpha_1$ *Centauri*—

$$\Delta\alpha \cos\delta = 2''\cdot123 + 0''\cdot864\,(t-1882\cdot0) - 0''\cdot0224\,(t-1882\cdot0)^2$$
$$\Delta\delta = 7''\cdot984 + 1''\cdot570\,(t-1882\cdot0) - 0''\cdot0764\,(t-1882\cdot0)^2$$

which represents from 1881 to 1883 within 0″·002 the places given by the following orbit :

* His Dissertation referred to in the Preface, p. 2.

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Periastron	T	=1875·740
Period	P	=80·34 years
Eccentricity	e	=0·5260
Angle from Periastron to Node ...	$\dot{\lambda}$	$=52^{\circ}\cdot50$
Inclination	i	$=79^{\circ}\cdot54$
Position Angle of Node	☊	$=25^{\circ}\cdot50-0^{\circ}\cdot007\ (t-1860)$.

These elements were obtained from those in his Dissertation by varying T, P, λ, and ☊, so as to make the orbit agree with our measures of position angle from 1881 to 1883 and still preserve the representation of the older observations.

The semi-major axis has been taken

$$=17''\cdot20,$$

a value which satisfies the numerous Heliometer measures of distance made by ELKIN and myself from 1881 to 1883.

The combination of these data gives for the motion of α_2 *Centauri*—

For 1881·0	$\Delta\alpha\cos\delta=-3''\cdot138$	$\Delta\delta=+1''\cdot608$
82·0	$=-3\cdot161$	$=+1\cdot532$
83·0	$=-3\cdot183$	$=+1\cdot456$

When these motions are converted into semi-revolutions of the micrometer screw, and projected on the lines α_2 *Centauri*—α and α_2 *Centauri*—β I obtained the following values of $\frac{\Delta s}{\Delta t}$:—

	1881·0.	1882·0.	1883·0.
	R	R	R
For α	−0·2465	−0·2428	−0·2391
β	+ ·2482	+ ·2446	+ ·2410

and these values have been employed in the reductions.

The parallax factors of α_2 *Centauri* for measures of its distance from the stars α and β are the following:—

From α	0·9390 R cos $(\odot-347^{\circ}\cdot65)$
β	·9424 R cos $(\odot-167^{\circ}\cdot01)$

Where R is the Earth's radius reckoned *unity* at mean distance from the

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Sun, and ⊙ denotes the Sun's longitude. The sum and difference of these expressions are—

For $\alpha+\beta$ ... ... 0·011 R cos (⊙ − 96°·0)
$\alpha-\beta$ ... ... 1·881 R cos (⊙ − 347°·3)

The maxima and minima of parallax for $\alpha-\beta$ therefore occur on March 7 and September 10 respectively.

The parallax factor for $\alpha-\beta$ is a very favourable one, whilst for our purposes the effect of parallax on the sum of the distances may be safely neglected.

The correction for aberration, in semi-revolutions of the screw, has been computed by the formula

$$aA+bB,$$

where A and B are the Bessel Day-numbers of the *Nautical Almanac*, and for—

Distance α.	Distance β.
log a = −6·9918	log a −6·8965
log b = +6·7608	log b +6·6463

The screen which I employed in making the observations consists of two folds of very dense wire gauze. This screen, when laid over the segment of the object-glass through which α_2 *Centauri* is viewed, reduces the appearance of its image in the field of view to that of a 7th magnitude star —in fact, to practical equality in colour and magnitude with the image of the comparison star α. The star β is quarter of a magnitude fainter than α or than the reduced image of α_2 *Centauri*, and is of a reddish colour.

The image of α_1 *Centauri* was not obliterated by the screen, but remained an inconveniently conspicuous object, having the appearance of a star of $8\frac{1}{4}$ magnitude. The discs of the component stars, however, were so sharply defined and so widely separated, that I did not think any systematic error in passing the image of α or β through that of α_2 *Centauri* could be created by the neighbourhood of α_1 *Centauri*, and, therefore, did not employ a reversing prism, as in my observations of *Mars* at Ascension. The neglect of this precaution has greatly increased the labour of this investigation both in observation and reduction.

The series consists of 106 observations, of which five are rejected on account of the unfavourable circumstances of definition under which they

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were made, and of the remaining 101 observations 17 depend on "half-sets" only, and receive half-weight in the subsequent reductions; the rest are "complete sets," as so defined in the Introduction.

The observations were begun July 5, 1881, and continued with regularity till October 1882, except during the early part of August 1881, when I paid a short visit to Natal (in connection with the longitude operations then in progress), and during November of the same year, when *α Centauri* is too near the Sun for observation at suitable altitudes. The observations were renewed, for after-mentioned reasons, on Feb. 18, 1883, and brought to a close on May 23 of that year.

It was our custom to reduce the observations (approximately) the following morning after they were made; and in April 1882, when it became possible to make observations in the evening East of the Meridian, and before sunrise to the West of it, I soon obtained unquestionable evidence of the existence of considerable systematic error depending on the hour angle of observation.

I, therefore, lost no opportunity of making observations to determine these errors. Also from the 25th of that month I carefully noted whether I inclined my head so that the line joining my eye was parallel to, or at right angles with, the line joining the stars under measurement; or rather I recorded whether, by motion in position angle, the star discs were passed through each other in a direction at right angles to, or parallel with, the line joining my eyes. In my note books the former condition is indicated thus the latter condition thus —●—●—.

As Dr. Elkin was simultaneously engaged in like work, and did not then intend to remain at the Cape so long as another year, it was not possible for me, without seriously damaging the value of his work, to obtain so many observations for the purposes in question as I might otherwise have been able to make; therefore, for the purpose of strengthening the determination of these systematic errors, I renewed the investigations in 1883.

The results of all these observations are given in the following Tables.

The *first* column gives a rotation number for convenience of reference.

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The *second* column gives the mean Sidereal time of the observations.

The *third* and *fourth* columns refer to the quality of the definition as explained in the Introduction (page 12).

The *fifth* column gives the mean of the external Thermometer readings made immediately before and after the observations.

The *sixth* and *seventh* columns, marked α and β, give the observed distance of α_2 *Centauri* from the comparison stars α and β respectively, (corrected for Screw-Error,* Run,* Refraction,* Aberration,* and Proper Motion)* expressed in semi-revolutions of the Micrometer screw, for 1882·0.

The *eighth* column gives the difference of the distances $(\alpha-\beta)$ corrected to normal scale value. That is to say, a mean value of $\alpha+\beta$ is adopted from the whole of the observations, and the difference of any particular observed value of $(\alpha+\beta)$ from the adopted mean is considered to be due, apart from accidental errors of observation, to difference of the instantaneous scale-value from the mean.

Thus, if

S_0 = the mean sum of the distances $= 536^{R}\cdot0510$

S = any particular observed sum of the distances

D_0 = the mean difference of the distances $= 60\cdot000$

D = any particular observed difference of the distances

ΔD = the correction to be applied to D to reduce to normal scale value

then

$$\Delta D = (S_0 - S) \times \frac{D}{S},$$

or practically

$$\Delta D = \frac{D_0}{S_0}(S_0 - S) = 0\cdot112\,(S_0 - S).$$

The last column contains the inferred or noted direction of the passage

* The separate values of these corrections will be published in the Annual Volumes of the Cape observations.

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of the images through each other (by slow motion in position angle) with reference to the observer's eyes.

The Symbol : indicates that the stars so pass through each other at right angles to the line joining the observer's eyes.

„ •• indicates that this motion took place parallel to the line of the eyes.

If the marks are enclosed thus (:) (••), it is to be understood that the fact was noted in the observing book; if not so enclosed, the position has been inferred.

Measures of α_2 Centauri from Stars α and β.

Rotation No.	Date. 1881.	Sidereal Time.	Images.	Steadiness.	Temperature.	α	β	α−β+ΔD	Direction in which images cross relative to line joining observer's eyes.
		h m			F.°	R	R	k	
1	July 5	16 30	2–3	3	49·8	298·0331	238·0799	59·9463	: W.
2	6	15 50	2–3	2–3	58·5	·0255	·0857	·9331	: W.
3	7	18 25	3	3	56·5	·0449	·1178	·9146	: W.
4	8	18 6	3	3	49·0	·0341	·0959	·9294	: W.
5	11	16 42	1–2	1–2	49·7	·0047	·0809	·9199	: W.
6	12	18 42	3	3	42·2	·0106	·0922	·9126	: W.
7	19	16 50	1–2	2–3	42·5	298·0008	·0785	·9191	: W.
8	Aug. 28	18 15	3–4	3–4	56·0	297·9493	·0675	[·8846]	: W.
9	29	18 7	2–?	2–3	57·8	·9309	·0673	·8695	: W.
10	30	17 26	2	2	55·6	·9331	·0604	·8791	: W. ½ set
11	Sept. 3	18 49	1	2	47·3	·9439	·0694	·8787	: W.
12	7	19 20	3	3	54·8	·9590	·0808	·8795	: W.
13	13	18 37	2	3	49·3	·9754	·0854	·8889	: W.
14	20	19 7	2	3–4	58·0	·9405	·0876	·8555	: W.
15	23	19 17	3–4	4	59·0	·9315	·0651	[·8725]	: W. ½ set
16	26	19 36	1–2	2–3	53·2	·9816	·0889	·8905	? W.
17	Oct. 4	20 4	1–2	2–3	61·3	·9656	·0473	·9226	•• W.
18	6	21 41	1–2	3–4	53·2	·9869	·0654	·9214	•• W.
19	7	20 11	1–2	2	58·0	·9735	·0756	·8981	•• W.
20	12	20 45	3	3	59·3	·9695	·0884	·8803	•• W.
21	28	21 3	2	3–4	54·3	297·9629	·0289	·9406	•• W.
22	Dec. 1	8 7	3	3	55·0	298·0179	·0401	59·9770	: E. ½ set
23	10	8 52	1–2	2–3	60·5	·0383	·0331	60·0029	: E. ½ set
24	18	9 4	1–2	1–2	57·6	·0414	238·0245	·0152	: E.
25	25	9 24	1–2	2–3	59·5	·0318	237·9921	·0427	: E.
26	26	9 49	1–2	3	57·0	·0419	238·0073	·0348	: E.
27	1882. Jan. 7	9 7	1	1–2	60·0	·0410	237·9865	·0571	: E.
28	11	10 25	2	2	63·0	·0188	·9653	·0610	? E.
29	18	10 49	1–2	2	62·0	·0511	·9777	·0759	? E.
30	28	8 56	3	3	69·1	·1018	·9895	·1078	: E.

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Measures of α_2 *Centauri*—continued.

Rotation No.	Date. 1882.	Sidereal Time.	Images.	Steadiness.	Temperature.	α	β	$\alpha-\beta+\Delta D$	Direction in which images cross relative to line joining observer's eyes.
					F.	R	R	R	
31	Feb. 9	12 47			68 8	298·0682	237·9800	60·0885	.. E.
32	10	9 10	2–3	3–4	63·0	·0811	·9600	·1222	: E.
33	13	8 58	2–3	3	69·5	·0715	·9667	·1062	: E.
34	22	9 31	2–3	3	52·0	·0847	·9735	·1104	: E.
35	23	9 31	3	3–4	65·0	·0705	·9498	·1241	: E.
36	Mar. 4	13 9	1–2	2–3	55·0	·0614	·9649	·0993	.. E.
37	5	9 6	2	2	65·0	·0699	·9450	·1289	: E.
38	6	11 23	1–2	2–3	56·0	·0737	·9597	·1160	.. E.
39	9	9 45	2–3	3	62·0	·0580	·9369	·1274	: E. ½ set
40	10	11 53	2	2–3	65·5	·0642	·9701	·0960	.. E.
41	11	9 36	2	4	56·0	·0731	·9285	[·1501]	: E. ½ set
42	14	9 17	2	2–3	63·5	·0691	·9527	·1197	: E.
43	15	12 7	1–2	2–3	62·3	·0479	·9503	·1035	.. E.
44	17	16 42	1–2	2	59·3	·0514	·9581	·0979	: W.
45	21	9 9	3	3–4	64·3	·0671	·9278	·1456	: E.
46	23	9 8	2–3	3	67·5	·0618	·9279	·1408	: E.
47	31	8 52	1–2	2	65·0	·0563	·9457	·1161	: E.
48	April 2	10 33	2–3	3	62·0	·0659	·9717	·0957	? E.
49	7	18 17	2	2–3	62·0	·0591	·9710	·0904	: W.
50	8	10 12	1–2	2	60·5	·0633	·9635	·1025	: E.
51	9	18 37	2	2–3	61·5	·0526	·9839	·0703	: W.
52	11	9 41	1	2	61·5	·0404	·9466	·1010	: E.
53	13	18 40	1–2	2	59·0	·0425	·9785	·0673	: W.
54	25	11 47	1–2	2	58·5	·0440	·9707	·0774	(..)E.
55	28	11 55	1–2	1–2	58·0	·0348	·9590	·0822	(..)E. ½ set
56	May 7	20 27	2	2–3	49·3	·0444	·9862	·0605	(..)W.
56a	9	9 58	2	2–3	55·0	·0330	·9569	·0829	(:) ½
57	9	20 22	2	2–3	57·3	·0584	·9797	·0801	(..)W.
58	18	19 38	2	3	45·3	·0137	·9917	·0271	(:)W.
59	19	11 56	2	2–3	56·8	·0226	·9933	·0332	(..)E.
60	22	10 19	1–2	2–3	54·8	·0168	·9795	·0434	(..)E.
61	26	10 29	2	2–3	59·0	298·0002	237·9575	60·0531	(:)E.
62	26	17 45	2–3	3	60·0	297·9839	238·0077	59·9829	(:)W.
63	28	10 21	2–3	3	51·5	·9997	237·9732	60·0352	(:)E.
64	29	10 7	2	2–3	54·0	298·0052	·9678	·0461	(:)E. ½ set
65	June 13	11 59	2	2	63·8	·1299	238·1231	59·9842	Prism E.
66	13	19 2	2–3	2	59·0	·1182	·1038	·9953	Prism W.
67	19	19 25	1–2	1–2	57·8	·1225	·1383	·9607	(:)W.

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Measures of α_2 Centauri—continued.

Rotation No.	Date. 1882.	Sidereal Time.	Images.	Steadiness.	Temperature.	α	β	$\alpha-\beta+\Delta D$	Direction in which images cross relative to line joining observer's eyes.
					F.	R	R	R	
68	June 21	18 42			56·3	298·0869	238·1235	59·9456	: W.
69	24	20 10	2–3	2–3	53·0	·0990	·1103	·9710	(··)W.
70	29	19 10	1–2	3	46 0	298 0719	·1037	·9542	(:)W.
71	30	19 16	1	2–3	43·5	297 9801	·0484	·9342	(:)W.
72	July 1	20 41	2	2	46·5	·9894	·0383	·9537	(··)W.
73	11	17 53	2	2–3	51·0	·9675	·0489	·9225	(:)W. ½ set
74	27	17 29			52·0	·9667	·1032	·8614	(:)W. ½ set
75	31	21 1	2–3	3	55·5	·9559	·0181	·9464	(··)W. ½ set
76	Aug. 1	17 19	2–3	2–3	57·0	·9723	·0785	·8938	(:)W. ½ set
77	4	17 43	3	3	55·5	·9767	·0727	[·9042]	¼ set for β Cent. only
78	18	18 38	2–3	2–3	52·5	·9666	·0901	·8759	(:)W. ½ set
79	19	18 29	2–3	3	52·0	·9656	·0892	·8760	(:)W.
80	21	19 21	1–2	2–3	53·0	·9555	·0870	·8695	(:)W.
81	23	18 9	2	2–3	51·0	·9463	·0979	·8492	(:)W. ½ set
82	Sept. 1	18 43	2	2–3	48·8	·9767	·1015	·8722	(:)W.
83	8	18 55	2	3	55·8	·9500	·0972	·8532	(:)W.
84	14	19 1	1–2	1–2	56·5	·9681	·0974	·8691	(:)W.
85	25	19 50			54·0	·9967	·0974	·8945	(··)W. ½ set
86	Oct. 1	20 39	1–2	2	55·0	·9265	·0516	·8831	(··)W.
87	2	20 21	2	2	58·8	297 9685	238·0291	59·9454	·· W.
88	1883. Feb. 18	10 4	2	2	66·0	298·1110	237·9939	60·1111	(:)E. ½ set
89	Mar. 8	11 15	3	3·4	60·0	·1322	·9886	[·1358]	(··)E.
90	27	11 46	2	2	63·0	·0740	·9724	·1021	(··)E.
91	April 5	10 9	2–3	2–3	55·5	·0891	·9709	·1172	(:)E.
92	5	17 51	2–3	2–3	57·4	·0513	237·9941	·0578	(:)W.
93	9	17 45	3	3	50·3	·0577	238·0195	·0353	(:)W. ½ set
94	11	18 8	1–2	2–3	51·3	·0664	237·9968	·0682	: W.
95	15	11 3	2	2	66·3	·0832	238·0026	·0767	(··)E.
96	15	17 35	2–3	3	62·3	·0665	·0104	·0532	(:)W. ½ set
97	16	11 28			62·0	·0895	238·0507	·0288	(··)E. ½ set
98	23	10 25	1–2	2–3	56·8	·0814	237·9773	·1032	(:)E.
99	23	19 35	2	2	57·0	·0474	238·0005	·0472	(:)W.
100	28	18 29	1–2	2	56·0	·0515	·0084	·0421	(:)W.
101	May 12	11 56	1–2	3	50·3	·0627	·0039	60·0571	(··)E.
102	12	18 5	1–2	2–3	45·0	·0375	·0379	59·9969	(:)W.
103	19	11 44	2	2	49·0	·0641	·0157	60·0452	·· E.
104	23	10 24	2	3	55·3	·0702	·0099	·0570	(:)E.
105	23	17 24			49·0	·0572	·0402	·0118	: W.

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In order more easily to consider the systematic errors of these observations, I prepared a diagram (Plate II., fig. 1), in which the ordinate of the curve is time, and the abscissa is $= 0^{R}\cdot112\ R\cos(\odot - 347^{\circ}\cdot3)$; in plotting the observations the mean value of $(\alpha-\beta)$ is assumed $60^{R}\cdot000$.

Observations made at great hour angles East are denoted thus ... ... ⊕

„ small „ East „ ... ... ⊖

„ small „ West „ ... ... ⊖

„ great „ West „ ... ... —o—

These symbols also indicate whether motion of the tube in position angle caused the images of the stars to cross through each other at right angles to, or parallel with, the line joining the observer's eyes. At great hour angles East, and at small hour angles West, the stars are nearly horizontal, and therefore motion in position angle causes the stars to pass vertically through each other (*i.e.* at right angles to the line joining the observer's eye), whilst the stars became more nearly vertical at small hour angles East, and great hour angles West, as will be evident from the following little table, giving the values of $p-q$ (where p is the position angle and q the parallactic angle) :

East.		West.	
Sid. Time.	$(p-q)$	Sid. Time.	$(p-q)$
h m	°	h m	°
8 31·6	71·5	15 31·6	296·0
9 31·6	59·4	16 31·6	273·1
10 31·6	46·3	17 31·6	254·8
11 31·6	31·3	18 31·6	239·8
12 31·6	13·0	19 31·6	226·7
13 31·6	350·1	20 31·6	214·7
		21 31·6	203·1

For the observations on and after April 25, 1882, there is never any doubt as to the position of the observer's head, because from that date, as already stated, the position in question has been regularly recorded. I therefore arranged these observations in order of Sidereal time, and find that the observation made at smallest Eastern hour angle, denoted thus (··) is

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No. 60 (10^h 19^m), and the observations of greatest Eastern hour angle, denoted thus (:), is No. 95 (11^h 3^m). Previous to 10^h 36^m $p-q$ is greater than 45°, so that I have, as a rule, avoided making observations near that time, because of having to incline the head to an inconvenient extent; and all observations made between 10^h 0 and 11^h 0 I have marked (?) (doubtful as to position of the head). The observation made at the greatest Western hour angle, which is marked thus (:) is No. 58 (19^h 38^m); and that made at the smallest Western hour angle marked (..) is No. 85 (19^h 50^m). At 19^h 40^m $(p-q)$ is $=225°$, previous to that hour the stars are more nearly horizontal, and after it more nearly vertical. The only observation West of the Meridian for which the position of the head appears to be doubtful is No. 16, made at 19^h 36^m, and I have so regarded it in the after discussion. Observation No. 12 (19^h 20^m) has the largest hour angle, which I have marked : , and No. 17 (20^h 4^m) has the smallest hour angle, which I have marked ·· , and I think there is little doubt with regard to either of them.

A glance at the diagram, at the times when nearly simultaneous observations were made both East and West of the Meridian, will show that, as a rule, the greatest values of $\alpha-\beta+\Delta D$ occur with observations marked ⦶ and the smallest values with those marked ⦷—that is, when the corresponding values of $p-q$ differ about 180°—, and that the observations marked —●— and —o— occupy intermediate positions. It is also clear that any discussion in which these systematic errors are not taken into account will give much too large a value of the parallax.

Beyond these general conclusions it is not easy to go without a more formal discussion; nor, without such discussion, is it easy to decide whether the systematic corrections are a function of $(p-q)$, or whether they depend entirely on the direction of measurement with respect to the line joining the observer's eyes.

It will at least be of some interest to discuss the observations on both hypotheses, and I have accordingly done so.

The general type of the equation is

$$x + ty + R.\cos(\odot - 347°{\cdot}3)\,z = D - D_0.$$

where t is the time in years from 1882·0, and the parallax π is

$$= \frac{z}{1{\cdot}881}.$$

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Neither in this nor in any of the following investigations has the usual term been introduced which expresses the effect of an unknown difference between the constant of aberration of the principal star and that of the comparison stars.*

In the first of the following discussions I shall suppose that the systematic error entirely depends on the position of the line joining my eyes with reference to the direction of measurement. Therefore, in the above typical equation I write for x—

$x_{/}$	when the observation is marked	: E. or (:) E., *i.e.*	in the diagram	
$x_{//}$	„	„ .. E. or (..) E.	„	
$x_{///}$	„	„ : W. or (:) W.	„	
$x_{////}$	„	„ .. W. or (..) W.	„	

Also, as there is still some uncertainty as to the relative masses and orbital motion of the two components of *α Centauri*, I have introduced the term y', whose co-efficient is the square of the time in years from 1882·0.

The following are the equations of condition so formed :

Equations of Condition.

						R	p.
1	$x_{///}$	− ·492y	+ ·242y'	− ·455z	=	− ·054	
2	$x_{///}$	− ·490	+ ·240	− ·471		− ·067	
3	$x_{///}$	− ·487	+ ·237	− ·487		− ·085	
4	$x_{///}$	− ·485	+ ·235	− ·502		− ·071	
5	$x_{///}$	− ·476	+ ·227	− ·552		− ·080	
6	$x_{///}$	− ·473	+ ·224	− ·573		− ·087	
7	$x_{///}$	− ·454	+ ·206	− ·652		− ·081	
8	$x_{///}$	− ·345	+ ·119	− ·988		[− ·115]	
9	$x_{///}$	− ·342	+ ·117	− ·991		− ·131	
10	$x_{///}$	− ·340	+ ·116	− ·994		− ·121	½

* I am assured by Prof. Newcomb, relative to his experiments on the velocity of light with an apparatus which deflected the image of a slit 3° on each side of a mean position in consequence of the time of passage of light, that there is no appearance whatever of a spectrum in the image, nor indeed the slightest iridescence, as there certainly would be if the velocity of red and blue light differed by so much as $\frac{1}{1000}$ part of the whole. It is difficult, therefore, to believe in the reality of such a term.

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***Equations of Condition*—continued.**

							R	
11			x_{III}		$-\cdot328y$	$+\cdot108y'$	$-1\cdot003z$	$=-\cdot121$	
12			x_{III}		$-\cdot318$	$+\cdot101$	$-1\cdot005$	$-\cdot121$	
13			x_{III}		$-\cdot301$	$+\cdot091$	$-1\cdot003$	$-\cdot111$	
14			x_{III}		$-\cdot282$	$+\cdot080$	$-\cdot987$	$-\cdot145$	
15			x_{III}		$-\cdot274$	$+\cdot075$	$-\cdot975$	$[-\cdot128]$	
16			?		$-\cdot265$	$+\cdot070$	$-\cdot960$	$[-\cdot110]$	
17				x_{IIII}	$-\cdot243$	$+\cdot059$	$-\cdot918$	$-\cdot077$	
18				x_{IIII}	$-\cdot238$	$+\cdot057$	$-\cdot895$	$-\cdot079$	
19				x_{IIII}	$-\cdot235$	$+\cdot055$	$-\cdot887$	$-\cdot102$	
20				x_{IIII}	$-\cdot222$	$+\cdot049$	$-\cdot843$	$-\cdot120$	
21				x_{IIII}	$-\cdot178$	$+\cdot032$	$-\cdot662$	$-\cdot059$	
22	x_I				$-\cdot084$	$+\cdot007$	$-\cdot124$	$-\cdot023$	$\frac{1}{2}$
23	x_I				$-\cdot059$	$+\cdot003$	$+\cdot034$	$+\cdot003$	$\frac{1}{2}$
24	x_I				$-\cdot037$	$+\cdot001$	$+\cdot173$	$+\cdot015$	
25	x_I				$-\cdot018$	$+\cdot000$	$+\cdot291$	$+\cdot043$	
26	x_I				$-\cdot016$	$+\cdot000$	$+\cdot307$	$+\cdot035$	
27	x_I				$+\cdot018$	$+\cdot000$	$+\cdot498$	$+\cdot057$	
28		?			$+\cdot029$	$+\cdot001$	$+\cdot557$	$[+\cdot061]$	
29		?			$+\cdot048$	$+\cdot002$	$+\cdot653$	$[+\cdot076]$	
30	x_I				$+\cdot076$	$+\cdot006$	$+\cdot774$	$+\cdot108$	
31		x_{II}			$+\cdot109$	$+\cdot012$	$+\cdot888$	$+\cdot089$	
32	x_I				$+\cdot111$	$+\cdot012$	$+\cdot894$	$+\cdot122$	
33	x_I				$+\cdot119$	$+\cdot014$	$+\cdot915$	$+\cdot106$	
34	x_I				$+\cdot144$	$+\cdot021$	$+\cdot964$	$+\cdot110$	
35	x_I				$+\cdot146$	$+\cdot021$	$+\cdot968$	$+\cdot124$	
36		x_{II}			$+\cdot171$	$+\cdot029$	$+\cdot991$	$+\cdot099$	
37	x_I				$+\cdot174$	$+\cdot030$	$+\cdot992$	$+\cdot129$	
38		x_{II}			$+\cdot177$	$+\cdot031$	$+\cdot992$	$+\cdot116$	
39	x_I				$+\cdot185$	$+\cdot034$	$+\cdot992$	$+\cdot127$	$\frac{1}{2}$
40		x_{II}			$+\cdot188$	$+\cdot035$	$+\cdot992$	$+\cdot096$	
41	x_I				$+\cdot190$	$+\cdot036$	$+\cdot992$	$[+\cdot150]$	
42	x_I				$+\cdot198$	$+\cdot039$	$+\cdot990$	$+\cdot120$	
43		x_{II}			$+\cdot201$	$+\cdot040$	$+\cdot986$	$+\cdot104$	
44			x_{III}		$+\cdot207$	$+\cdot043$	$+\cdot980$	$+\cdot098$	
45	x_I				$+\cdot217$	$+\cdot047$	$+\cdot968$	$+\cdot146$	
46	x_I				$+\cdot223$	$+\cdot050$	$+\cdot959$	$+\cdot141$	
47	x_I				$+\cdot245$	$+\cdot060$	$+\cdot915$	$+\cdot116$	

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Equations of Condition—continued.

							R	
48	?			+ ·250y	+ ·062y'	+ ·901z	=[+ ·096]	
49		x_{III}		+ ·265	+ ·070	+ ·860	+ ·090	
50	x_I			+ ·267	+ ·071	+ ·853	+ ·103	
51		x_{III}		+ ·270	+ ·073	+ ·842	+ ·070	
52	x_I			+ ·275	+ ·076	+ ·826	+ ·101	
53		x_{III}		+ ·281	+ ·079	+ ·804	+ ·067	
54		x_{II}		+ ·313	+ ·098	+ ·671	+ ·077	
55		x_{II}		+ ·321	+ ·103	+ ·631	+ ·082	½
56			x_{IIII}	+ ·347	+ ·120	+ ·502	+ ·061	
56*a*	x_I			+ ·351	+ ·123	+ ·479	+ ·083	
57			x_{IIII}	+ ·352	+ ·124	+ ·473	+ ·080	
58		x_{III}		+ ·377	+ ·142	+ ·333	+ ·027	
59		x_{II}		+ ·379	+ ·144	+ ·325	+ ·033	
60		x_{II}		+ ·387	+ ·150	+ ·276	+ ·043	
61	x_I			+ ·398	+ ·158	+ ·209	+ ·053	
62		x_{III}		+ ·399	+ ·159	+ ·204	− ·017	
63	x_I			+ ·403	+ ·162	+ ·176	+ ·035	
64	x_I			+ ·406	+ ·165	+ ·160	+ ·046	½
65	Prism E.			+ ·447	+ ·200	− ·094	[− ·016]	
66	Prism W.			+ ·448	+ ·201	− ·097	[− ·005]	
67		x_{III}		+ ·464	+ ·215	− ·199	− ·039	
68		x_{III}		+ ·470	+ ·221	− ·229	− ·054	
69			x_{IIII}	+ ·478	+ ·228	− ·280	− ·029	
70		x_{III}		+ ·492	+ ·242	− ·359	− ·046	
71		x_{III}		+ ·494	+ ·244	− ·376	− ·066	
72			x_{IIII}	+ ·497	+ ·247	− ·394	− ·046	
73		x_{III}		+ ·524	+ ·275	− ·541	− ·078	½
74		x_{III}		+ ·568	+ ·323	− ·747	− ·139	½
75			x_{IIII}	+ ·579	+ ·335	− ·792	− ·054	½
76		x_{III}		+ ·581	+ ·338	− ·801	— ·106	½
77		x_{III}		+ ·590	+ ·348	− ·830	[− ·096]	
78		x_{III}		+ ·628	+ ·394	− ·941	− ·124	½
79		x_{III}		+ ·631	+ ·398	− ·947	− ·124	
80		x_{III}		+ ·636	+ ·404	− ·958	− ·131	
81		x_{III}		+ ·641	+ ·411	− ·968	− ·151	½
82		x_{III}		+ ·666	+ ·444	− ·999	− ·128	
83		x_{III}		+ ·685	+ ·469	−1·005	− ·147	

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Equations of Condition—continued.

								R	
84			x_{III}		+ ·702y	+ ·493y'	−1·002z	= − ·131	
85				x_{IIII}	+ ·732	+ ·536	− ·967	− ·106	½
86				x_{IIII}	+ .748	+ ·560	− ·933	− ·117	
87				x_{IIII}	+ ·751	+ ·564	− ·926	− ·055	
88	x_I				+1·132	+1·281	+ ·944	+ ·111	½
89		x_{II}			+1·182	+1·397	+ ·993	[+ ·136]	
90		x_{II}			+1·234	+1·523	+ ·940	+ ·102	
91	x_I				+1·258	+1·583	+ ·879	+ ·117	
92			x_{III}		+1·259	+1·585	+ ·878	+ ·058	
93			x_{III}		+1·270	+1·613	+ ·844	+ ·035	½
94			x_{III}		+1·276	+1·628	+ ·826	+ ·068	
95		x_{II}			+1·286	+1·654	+ ·789	+ ·077	
96			x_{III}		+1·287	+1·656	+ ·786	+ ·053	½
97		x_{II}			+1·289	+1·661	+ ·778	+ ·029	½
98	x_I				+1·308	+1·711	+ ·698	+ ·103	
99			x_{III}		+1·309	+1·713	+ ·694	+ ·047	
100			x_{III}		+1·322	+1·748	+ ·631	+ ·042	
101		x_{II}			+1·360	+1·850	+ ·435	+ ·057	
102			x_{III}		+1·360	+1·850	+ ·432	− ·003	
103		x_{II}			+1·379	+1·902	+ ·328	+ ·045	
104	x_I				+1·390	+1·932	+ ·262	+ ·057	
105			x_{III}		+1·390	+1·932	+ ·261	+ ·012	

In forming normals the following equations have been rejected, viz.:—

8, 15, and 41, on account of the unfavourable circumstances of definition under which the observations were made. (*See* Introduction, p. 12.)

16, 28, 29, 48, 89, because uncertain as to the position of the head.

65, 66, because the prism of reversion was employed, and the observations are therefore not comparable with the others.

77, because it depends on a "quarter set" of observations only, and therefore on observations unsymmetrically arranged (*see* p. 8).

The following equations have received half weight because they depend on "half sets" of observations:

10, 22, 23, 39, 55, 64, 73, 74, 75, 76, 78, 81, 85, 88, 93, 96, 97.

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The resulting normals are then—

$24{\cdot}50x_{,}$				$+\ 8{\cdot}04y$	$+\ 6{\cdot}86y'$	$+15{\cdot}99z$	$=+2{\cdot}16$
	$+13{\cdot}00x_{,,}$			$+\ 7{\cdot}99$	$+\ 8{\cdot}35$	$+\ 9{\cdot}32$	$+0{\cdot}99$
		$+37{\cdot}00x_{,,,}$		$+12{\cdot}61$	$+18{\cdot}82$	$-\ 8{\cdot}69$	$-1{\cdot}78$
			$+12{\cdot}00x_{,,,,}$	$+\ 2{\cdot}71$	$+\ 2{\cdot}53$	$-\ 6{\cdot}64$	$-0{\cdot}62$
$8{\cdot}04$	$+\ 7{\cdot}99$	$+12{\cdot}61$	$+\ 2{\cdot}71$	$+36{\cdot}56$	$+37{\cdot}32$	$+14{\cdot}95$	$+1{\cdot}42$
$6{\cdot}86$	$+\ 8{\cdot}35$	$+18{\cdot}82$	$+\ 2{\cdot}53$	$+37{\cdot}32$	$+47{\cdot}59$	$+11{\cdot}11$	$+0{\cdot}84$
$15{\cdot}99$	$+\ 9{\cdot}32$	$-\ 8{\cdot}69$	$-\ 6{\cdot}64$	$+14{\cdot}95$	$+11{\cdot}11$	$+48{\cdot}42$	$+5{\cdot}65$

Their solution and the substitution of the computed values of the unknowns give—

	Weight.	Corresponding Probable Error.	
R		R	
$x_{,} = +0{\cdot}0178$	17·2	$\pm 0{\cdot}0022$	
$x_{,,} - {\cdot}0003$	9·5	$\pm {\cdot}0030$	
$x_{,,,} - {\cdot}0214$	24·7	$\pm {\cdot}0018$	$[pvv] = 0{\cdot}0163$
$x_{,,,,} + {\cdot}0093$	9·7	$\pm {\cdot}0029$	
$y - {\cdot}0026$	6·2	$\pm {\cdot}0037$	$\epsilon^2 = 0{\cdot}000185$
$y' - {\cdot}0002$	8·2	$\pm {\cdot}0032$	
$z \quad +0{\cdot}1092$	22·3	$\pm {\cdot}0019$	

or

$$\pi = +0''{\cdot}747 \pm 0''{\cdot}0133,$$

and the probable error of one observation is $= \pm 0^{R}{\cdot}00918 = \pm 0''{\cdot}1181$.

The residuals from this solution are given in a following Table (pp. 30–32) in the column marked I.

In this solution, however, it is assumed that the systematic corrections $x_{,}$ $x_{,,}$ etc., are constant throughout the investigation. This is by no means necessarily the case, since there is sufficient change in the relative positions of α_1 and α_2 *Centauri* (viz. from $p=193°$, $s=7''{\cdot}4$ at 1881·5 to $p=198°$, $s=10''{\cdot}7$ at 1883·5) to account for possible change in these systematic errors.

However, since there is little change in the position angle, and as the distance changes nearly proportionately to the time, we certainly cannot be far in error to assume that the change in the systematic errors (if any) is

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also proportional to the time. A glance at the diagram will show that if we exclude the equations numbered from 1 to 24, we have two groups of observations made near the maximum of parallax in 1882 and 1883 respectively, each of which contains about an equal number of observations for the determination of systematic errors; and, therefore, if these systematic errors change proportionately with the time, they will be truly determined for the intermediate groups at the minimum of parallax.

Therefore, rejecting equation 24 and all equations preceding it, we have from the remaining equations the following normals, from which, however, y' (depending on the square of the time) cannot be determined.

$22{\cdot}50x_I$				$+\ 8{\cdot}15y$	$+15{\cdot}86z$	$=+2{\cdot}16-\ 6{\cdot}86y'$
	$13{\cdot}00x_{II}$			$+\ 7{\cdot}99$	$+\ 9{\cdot}32$	$+0{\cdot}99-\ 8{\cdot}35$
		$24{\cdot}50x_{III}$		$+17{\cdot}70$	$+\ 0{\cdot}49$	$-0{\cdot}56-16{\cdot}66$
			$7{\cdot}00x_{IIII}$	$+\ 3{\cdot}83$	$-\ 2{\cdot}44$	$-0{\cdot}19-\ 2{\cdot}28$
$8{\cdot}15$	$+7{\cdot}99$	$+17{\cdot}70$	$+3{\cdot}83$	$+34{\cdot}14$	$+10{\cdot}50$	$+0{\cdot}85-38{\cdot}33$
$15{\cdot}86$	$+9{\cdot}32$	$+\ 0{\cdot}49$	$-2{\cdot}44$	$+10{\cdot}50$	$+37{\cdot}35$	$+4{\cdot}31-12{\cdot}73$

whence—

	Weight.	Corresponding Probable Error.	
R		R	
$x_I = +0{\cdot}0206+0{\cdot}34y'$	12·1	$\pm 0{\cdot}0025$	
$x_{II} + {\cdot}0001+0{\cdot}39$	7·3	$\pm {\cdot}0033$	$[p.vv]=0{\cdot}0117$
$x_{III} - {\cdot}0230+0{\cdot}43$	11·6	$\pm {\cdot}0026$	
$x_{IIII} + {\cdot}0123+0{\cdot}46$	5·7	$\pm {\cdot}0037$	$\epsilon^2 = 0{\cdot}000172$
$y - {\cdot}0029-1{\cdot}53$	11·4	$\pm {\cdot}0026$	
$z + {\cdot}1085-0{\cdot}13$	18·6	$\pm {\cdot}00205$	

$$\pi = +0''{\cdot}742 = 0''{\cdot}0140,$$

and the probable error of one observation of weight *unity* is

$$= \pm {}^{R}0{\cdot}00885 = \pm 0''{\cdot}1138.$$

The residuals from this solution—nearly identical with those of the previous solution—are given in the column marked II. in the following Table :—

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Representation of the different Solutions.

Rotation No.	Direction of images crossing relative to observer's eyes	$p-q$	Factor of y	Factor of z	Residuals. I.	Residuals. II.	Residuals. III.	p
		°						
1	: W.	273·5	−0·492	− ·455	+0·016		+0·019	
2	: W.	288·5	·490	·471	+ 5		+ 7	
3	: W.	241·3	·487	·487	− 12		− 16	
4	: W.	245·9	·485	·502	+ 4		+ 2	
5	: W.	269·7	·476	·552	0		+ 4	
6	: W.	237·4	·473	·573	− 4		− 11	
7	: W.	267·1	·454	·652	+ 10		+ 14	
8	: W.	243·7	·345	·988	[ ]		[+ 11]	
9	: W.	245·7	·342	·991	− 2		− 4	
10	: W.	256·4	·340	·994	+ 8		+ 11	½
11	: W.	235·9	·328	1·003	+ 9		+ 3	
12	: W.	229·1	·318	1·005	+ 9		− 2	
13	: W.	238·6	·301	1·003	+ 19		+ 14	
14	: W.	231·9	·282	·987	− 16		− 26	
15	: W.	229·8	·274	·975	[ ]		[− 12]	
16	? W.	225·8	·265	·960	[ ]		+ 1	
17	.. W.	220·1	·243	·918	+ 14		+ 26	
18	.. W.	201·3	·238	·895	+ 9		+ 7	
19	.. W.	218·7	·235	·887	− 15		− 3	
20	.. W.	212·1	·222	·843	− 38		− 31	
21	.. W.	208·5	·178	·662	+ 3		+ 7	
22	: E.	76·2	·084	− ·124	− 28		− 15	½
23	: E.	67·4	·059	+ ·034	− 19		− 18	½
24	: E.	65·0	·037	·173	− 22		− 16	
25	: E.	61·0	·018	·291	− 7	− ·009	− 5	
26	: E.	55·7	− ·016	·307	− 16	− 19	− 15	
27	: E.	64·4	+ ·018	·498	− 15	− 18	− 14	
28	? E.	47·9	·029	·557	[ ]		− 12	
29	? E.	42·2	·048	·653	[ ]		− 6	
30	: E.	66·6	·076	·774	+ 6	+ 4	+ 6	
31	.. E.	7·6	·109	·888	− 7	− 7	− 11	
32	: E.	63·8	·111	·894	+ 7	+ 5	+ 8	
33	: E.	66·2	·119	·915	− 11	− 14	− 11	
34	: E.	59·5	·144	·964	− 12	− 15	− 11	
35	: E.	59·5	·146	·968	+ 1	− 1	+ 3	
36	.. E.	359·3	·171	·991	− 8	− 8	− 10	
37	: E.	64·6	·174	·992	+ 4	+ 1	+ 4	
38	.. E.	33·6	·177	·992	+ 9	+ 9	0	
39	: E.	56·6	·185	·992	+ 2	− 1	+ 5	½

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Representation of the different Solutions—continued.

Rotation No.	Direction of images crossing relative to observer's eyes	$p-q$	Factor of y	Factor of z	Residuals. I.	II.	III.	p
40	•• E.	26°·0	+0·188	+·992	− 11	− 11	− 19	
41	: E.	58·5	·190	·992	[−]		+ 27	
42	: E.	62·4	·198	·990	− 5	− 7	− 4	
43	•• E.	21·0	·201	·986	+ 3	− 3	− 9	
44	: W.	269·7	·207	·980	+ 13	+ 15	+ 16	
45	: E.	64·0	·217	·968	+ 23	+ 21	+ 24	
46	: E.	64·2	·223	·959	+ 19	+ 17	+ 20	
47	: E.	67·4	·245	·915	− 1	− 3	− 1	
48	? E.	46·0	·250	·901			− 13	
49	: W.	243·2	·265	·860	+ 18	+ 20	+ 14	
50	: E.	50·8	·267	·853	− 7	− 9	+ 38	
51	: W.	238·5	·270	·842	0	+ 2	− 6	
52	: E.	57·4	·275	·826	− 6	− 8	− 3	
53	: W.	237·9	·281	·804	+ 2	+ 4	− 5	
54	(••)E.	26·9	·313	·671	+ 5	+ 5	− 2	
55	(••)E.	24·6	·321	·631	+ 14	+ 14	+ 8	½
56	(••)W.	215·6	·347	·502	− 2	− 5	+ 7	
56a	(:)E.	53·9	·351	·479	+ 14	+ 11	+ 20	
57	(••)W.	216·5	·352	·473	+ 20	+ 17	+ 30	
58	(:)W.	225·4	·377	·333	+ 13	+ 15	− 1	
59	(••)E.	24·3	·379	·325	− 1	− 1	− 7	
60	(••)E.	49·2	·387	·276	+ 14	+ 14	+ 3	
61	(:)E.	46·8	·398	·209	+ 13	+ 11	+ 21	
62	(:)W.	251·2	·399	·204	− 15	− 15	− 16	
63	(:)E.	48·7	·403	·176	− 1	− 4	+ 6	
64	(:)E.	51·9	·406	+ ·160	+ 12	+ 9	+ 18	½
65	□ E.	23·5	·447	− ·094	[ ]		− 11	
66	■ W.	233·0	·448	·097	[ ]		+ 1	
67	(:)W.	228·1	·464	·199	+ 5	+ 7	− 6	
68	: W.	237·4	·470	·229	− 6	− 5	− 11	
69	(••)W.	218·9	·478	·280	− 7	− 9	+ 7	
70	(:)W.	231·3	·492	·359	+ 16	+ 17	+ 8	
71	(:)W.	230·0	·494	·376	− 2	− 1	− 11	
72	(••)W.	212·8	·497	·394	− 11	− 14	− 3	
73	(:)W.	249·1	·524	·541	+ 4	− 5	+ 5	½
74	(:)W.	255·5	·568	·747	− 35	− 33	− 30	½
75	(••)W.	208·9	·579	·792	+ 25	+ 21	+ 31	½
76	(:)W.	258·3	·581	·801	+ 4	+ 6	+	½
77	? W.	251·7	·590	·830	[ ]	[ ]	[+ 21]	

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Representation of the different Solutions—continued.

Rotation No.	Direction of images crossing relative to observer's eyes	$p-q$	Factor of y	Factor of z	Residuals. I.	Residuals. II.	Residuals. III.	p
78	(:)W.	238°3	+0·628	−·941	+ ·002	+ ·003	− ·001	½
79	(:)W.	240·4	·631	·947	+ 2	+ 4	+ 1	
80	(:)W.	228·9	·636	·958	− 3	− 2	− 12	
81	(:)W.	245·2	·641	·968	− 22	− 21	− 21	½
82	(:)W.	237·2	·666	·999	+ 4	+ 5	+ 1	
83	(:)W.	234·6	·685	1·005	− 14	− 13	− 19	
84	(:)W.	233·2	·702	1·002	+ 2	+ 3	− 4	
85	(··)W.	222·9	·732	·767	− 8	− 11	+ 6	½
86	(··)W.	213·2	·748	·933	− 23	− 26	− 12	
87	·· W.	216·7	·751	− ·926	+ 39	+ 35	+ 52	
88	(:)E.	52·6	1·132	+ ·944	− 6	− 9	0	½
89	(··)E.	35·7	1·182	·993	[ ]		[+ 29]	
90	(··)E.	27·2	1·234	·940	+ 3	+ 3	− 2	
91	(:)E.	51·4	1·258	·879	+ 7	+ 5	+ 14	
92	(:)W.	249·7	1·259	·878	− 13	− 11	− 12	
93	(:)W.	251·2	1·270	·844	− 32	− 30	− 30	½
94	: W.	245·4	1·276	·826	+ 3	+ 5	+ 2	
95	(··)E.	38·8	1·286	·789	− 5	− 5	− 13	
96	(:)W.	253·9	1·287	·786	− 8	− 6	− 5	½
97	(··)E.	32·3	1·289	·778	− 52	− 52	− 58	½
98	(:)E.	47·9	1·308	·698	+ 13	+ 10	+ 21	
99	(:)W.	226·0	1·309	·694	− 4	− 2	− 16	
100	(:)W.	240·4	1·322	·631	− 2	0	− 4	
101	(··)E.	24·3	1·360	·435	+ 14	+ 14	+ 10	
102	(:)W.	246·1	1·360	·432	− 25	− 23	− 24	
103	·· E.	27·8	1·379	·328	+ 13	+ 13	+ 9	
104	(:)E.	48·1	1·390	·262	+ 15	+ 12	+ 30	
105	: W.	256·9	1·390	·261	+ 9	+ 11	+ 14	

The first of these solutions shows that the term of the proper motion depending on the square of the time is quite insensible; and the second solution shows that no admissible value of such term will sensibly affect the deduced parallax.

The agreement of the values of the unknowns in both solutions goes to show that there has been no very sensible change in the personal errors during the series, and the reader can form a better opinion on this point by inspecting columns I. and II. of the Table given at pp. 30–32. It seems,

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therefore, legitimate to solve the whole of the equations, omitting the term depending on the square of the time ; and as the value of y' is practically insensible, the residuals from this solution will be identical (within $0^{R}\cdot001$) with those of the first solution.

Rejecting, therefore, the terms in y' and the normal in y' from solution I., and eliminating y and z with their respective weights, we obtain—

$$\begin{aligned} y &= -0^{R}\cdot0029, \quad \text{Weight } 21\cdot3, \quad \text{Probable error } \pm 0^{R}\cdot0020 \\ z &= +0\cdot1092, \quad \text{„ } 22\cdot6, \quad \text{„ } \pm 0\cdot0019 \end{aligned}$$

$$\pi = 0''\cdot747 \pm 0''\cdot0133.$$

If we assume that the adopted proper motion is free from error (*i.e.* reject y) we obtain—

$$z = +0^{R}\cdot1083, \quad \text{Weight } 25\cdot6.$$

$$\pi = 0''\cdot741 \pm 0''\cdot012.$$

It is now necessary to examine the influence of the various conditions of definition on the observations. The following Table exhibits the number of observations made under each condition of steadiness and quality of image.

Images.	Steadiness.						Undescribed.
	1	1-2	2	2-3	3	3-4	
1		1	2	1			
1-2		5	9	13	3	1	
2			11	15	2	3	
2-3			1	7	11	1	
3					9	3	
3-4						2	
Undescribed							6

It is evident, from inspection of this Table, that one cannot very thoroughly separate the effect of unsteadiness of the air from diffusion of

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the images. It seems best, under the circumstances, to discuss the relative precision of the observations when classed according to quality, and when classed according to steadiness of the images. We then obtain the following results :—

	1 and 1-2	2	2-3	3
		Steadiness of Images.		
Probable error of one observation	R ±0·0079	R ±0·0086	R ±0·0072	R ±0·0099
No. of observations ...	6	19	35	29
Apparent systematic difference from mean	−0·0033	+0·0008	+0·0011	+0·0002
		Quality of Images.		
Probable error of one observation	R ±0·0078	R ±0·0088	R ±0·0068	R ±0·0120
No. of observations ...	33	28	18	10
Apparent systematic difference from mean	−0·0006	+0·0038	+0·0007	−0·0053

If, in the case of images 3, we reject one observation (No. 20, with its residual $-0^{R}\cdot038=-0''\cdot49$) we obtain for the probable error of one observation $\pm0^{R}\cdot0093$, and for the apparent systematic difference from mean $-0^{R}\cdot0015$. There are only two other residuals nearly so great as this, and they occur in large groups, where they have consequently less influence. The conclusion appears to be, that except for images and steadiness 3, the observations are practically of equal weight, and that the latter class of observations should receive a weight of about 0·6. The number of observations I. 3, S. 3, however, is so comparatively limited, and they are so evenly distributed amongst the other observations, that another solution, with modified weights, would certainly produce no practical change in the values of the unknowns, though it would slightly diminish the probable error.

On the more important question as to the possible effect of atmospheric

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disturbance in creating systematic error, no trace of such effect is to be found in the preceding Table. To further examine this I have re-grouped the residuals as follows :—

Images.	Steadiness.	No. of Obs.	Mean Value of Residuals. R
1 and 1–2	1–2	6	−0·003
	2	10	− ·001
	2–3	13	± ·000
	3	4	+ ·006
2	2	9	+ ·005 (or rejecting 87) ·0000
	2–3	15	+ ·003
	3	4	+ ·005
2–3	2 and 2–3	7	− ·001
	3	11	+ ·002
3	3	10	− ·005 (or rejecting 20) −·002

There is thus hardly a case in which the mean difference exceeds the mean error, and we may conclude with certainty, especially in view of the tolerably uniform distribution of the conditions of definition, that these conditions produce no systematic effect on the result.

If the systematic errors are not due to the position of the line joining the observer's eyes with relation to the direction of measurement, but depend upon the direction of measurement with respect to the vertical only, then we may represent them by a periodic function of $(p-q)$, and write for $x_{,}$ $x_{,,}$ $x_{,,,}$ or $x_{,,,,}$ in the original equations,

$$x+\cos(p-q)\,\alpha+\sin(p-q)\,\beta+\cos 2(p-q)\,\gamma+\sin 2(p-q)\,\delta.$$

This substitution leads to the following equations of condition, omitting the terms in y' which have been proved to be insignificant.

Equations of Condition.

1	$x+$ ·034α	− ·998β	− ·991γ	− ·127δ	− ·492y	− ·455z	=	− ·054
2	$x+$ ·317	− ·949	− ·798	− ·600	− ·490	− ·471		− ·067
3	$x-$ ·480	− ·877	− ·539	+ ·842	− ·487	− ·487		− ·085
4	$x-$ ·409	− ·913	− ·666	+ ·744	− ·485	− ·502		− ·071

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Equations of Condition—continued.

5	x − ·006α	−1·000β	−1·000γ	+ ·011δ	− ·476y	− ·552z	= − ·080		
6	x − ·538	− ·842	− ·420	+ ·907	− ·473	− ·573	− ·087		
7	x − ·050	− ·998	− ·994	+ ·100	− ·454	− ·652	− ·081		
8	x − ·444	− ·897	− ·607	+ ·794	− ·345	− ·988	[− ·115]		
9	x − ·413	− ·911	− ·659	+ ·750	− ·342	− ·991	− ·131		
10	x − ·236	− ·972	− ·888	+ ·458	− ·340	− ·994	− ·121	½ set	
11	x − ·561	− ·827	− ·370	+ ·929	− ·328	−1·003	− ·121		
12	x − ·655	− ·756	− ·144	+ ·989	− ·318	−1·005	− ·121		
13	x − ·521	− ·853	− ·456	+ ·889	− ·301	−1·003	− ·111		
14	x − ·617	− ·787	− ·239	+ ·970	− ·282	− ·987	− ·145		
15	x − ·646	− ·763	− ·165	+ ·985	− ·274	− ·975	[− ·128]	½ set	
16	x − ·695	− ·719	− ·028	+ ·999	− ·265	− ·960	− ·110		
17	x − ·766	− ·645	+ ·170	+ ·985	− ·243	− ·918	− ·077		
18	x − ·931	− ·364	+ ·736	+ ·677	− ·238	− ·895	− ·079		
19	x − ·782	− ·626	+ ·218	+ ·976	− ·235	− ·887	− ·102		
20	x − ·847	− ·530	+ ·437	+ ·899	− ·222	− ·843	− ·120		
21	x − ·878	− ·478	+ ·544	+ ·839	− ·178	− ·662	− 059		
22	x + ·238	+ ·971	− ·885	+ ·462	− ·084	− ·124	− ·023	½ set	
23	x + ·384	+ ·923	− ·705	+ ·709	− ·059	+ ·033	+ ·003	½ set	
24	x + ·422	+ ·906	− ·643	+ ·766	− ·037	+ ·173	+ ·015		
25	x + ·485	+ ·875	− ·530	+ ·848	− ·018	+ ·291	+ ·043		
26	x + ·563	+ ·826	− ·366	+ ·930	− ·016	+ ·307	+ ·035		
27	x + ·432	+ ·902	− ·627	+ ·779	+ ·018	+ ·498	+ ·057		
28	x + ·671	+ ·741	− ·098	+ ·994	+ ·029	+ ·557	+ ·061		
29	x + ·740	+ ·672	+ ·096	+ ·995	+ ·048	+ ·653	+ ·076		
30	x + ·397	+ ·918	− ·685	+ ·729	+ ·076	+ ·774	+ ·108		
31	x + ·991	+ ·132	+ ·964	+ ·261	+ ·109	+ ·888	+ ·089		
32	x + ·441	+ ·897	− ·611	+ ·792	+ ·111	+ ·894	+ ·122		
33	x + ·403	+ ·915	− ·674	+ ·738	+ ·119	+ ·915	+ ·106		
34	x + ·507	+ ·862	− ·486	+ ·874	+ ·144	+ ·964	+ ·110		
35	x + ·507	+ ·862	− ·486	+ ·874	+ ·146	+ .968	+ ·124		
36	x +1·000	− ·012	+ ·998	− ·026	+ ·171	+ ·991	+ ·099		
37	x + ·429	+ ·903	− ·632	+ ·774	+ ·174	+ ·992	+ ·129		
38	x + ·833	+ ·553	+ ·387	+ ·922	+ ·177	+ ·992	+ ·116		
39	x + ·550	+ ·835	− ·393	+ ·919	+ ·185	+ ·992	+ ·127	½ set	
40	x + ·899	+ ·438	+ ·616	+ ·787	+ ·188	+ ·992	+ ·096		
41	x + ·523	+ ·853	− ·453	+ ·891	+ ·190	+ ·992	+ ·150	½ set	
42	x + ·463	+ ·886	− ·570	+ ·821	+ ·198	+ ·990	+ ·120		

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Equations of Condition—continued.

43	x + ·933α	+ ·358β	+ ·743γ	+ ·669δ	+ ·201y	+ ·986z	= + ·104	
44	x − ·006	− 1·000	− 1·000	+ ·012	+ ·207	+ ·980	+ ·098	
45	x + ·438	+ ·899	− ·616	+ ·788	+ ·217	+ ·968	+ ·146	
46	x + ·435	+ ·900	− ·621	+ ·783	+ ·223	+ ·959	+ ·141	
47	x + ·384	+ ·923	− ·705	+ ·709	+ ·245	+ ·915	+ ·116	
48	x + ·695	+ ·719	− ·034	+ ·999	+ ·250	+ ·901	+ ·096	
49	x − ·452	− ·892	− ·591	+ ·805	+ ·265	+ ·860	+ ·090	
50	x + ·630	− ·775	− ·202	+ ·980	+ ·267	+ ·853	+ ·103	
51	x − ·521	− ·853	− ·456	+ ·889	+ ·270	+ ·842	+ ·070	
52	x + ·538	+ ·843	− ·420	+ ·907	+ ·275	+ ·826	+ ·101	
53	x − ·532	− ·846	− ·434	+ ·900	+ ·281	+ ·804	+ ·067	
54	x + ·891	+ ·453	+ ·589	+ ·807	+ ·313	+ ·671	+ ·077	
55	x + ·909	+ ·416	+ ·653	+ ·756	+ ·321	+ ·631	+ ·082	½ set
56	x − ·813	− ·580	+ ·324	+ ·945	+ ·347	+ ·502	+ ·061	
56*a*	x + ·589	+ ·808	− ·304	+ ·952	+ ·351	+ ·479	+ ·083	
57	x − ·804	− ·595	+ ·292	+ ·956	+ ·352	+ ·473	+ ·080	
58	x − ·702	− ·712	− ·014	+ ·999	+ ·377	+ ·333	+ ·027	
59	x + ·911	+ ·412	+ ·660	+ ·750	+ ·379	+ ·325	+ ·033	
60	x + ·653	+ ·757	− ·146	+ ·989	+ ·387	+ ·276	+ ·043	
61	x + ·683	+ ·730	− ·065	+ ·997	+ ·398	+ ·209	+ ·053	
62	x − ·322	− ·947	− ·792	+ ·609	+ ·399	+ ·204	− ·017	
63	x + ·659	+ ·752	− ·130	+ ·992	+ ·403	+ ·176	+ ·035	
64	x + ·617	+ ·787	− ·239	+ ·971	+ ·406	+ ·160	+ ·046	½ set
65	x	These observations made			+ ·447	− ·094	− ·016	
66	x	with reversing prism			+ ·448	− ·097	− ·005	
67	x − ·668	− ·744	− ·107	+ ·993	+ ·464	− ·199	− ·039	
68	x − ·538	− ·842	− ·421	+ ·907	+ ·470	− ·229	− ·054	
69	x − ·779	− ·628	+ ·210	+ ·977	+ ·478	− ·280	− ·029	
70	x − ·624	− ·780	− ·217	+ ·976	+ ·492	− ·359	− ·046	
71	x − ·643	− ·765	− ·173	+ ·984	+ ·494	− ·376	− ·066	
72	x − ·840	− ·542	+ ·412	+ ·911	+ ·497	− ·394	− ·046	
73	x − ·356	− ·935	− ·747	+ ·665	+ ·524	− ·541	− ·078	½ set
74	x − ·250	− ·968	− ·875	+ ·484	+ ·568	− ·747	− ·139	½ set
75	x − ·875	− ·484	+ ·533	+ ·846	+ ·579	− ·792	− ·054	½ set
76	x − ·202	− ·979	− ·917	+ ·379	+ ·581	− ·801	− ·106	½ set
77	x − ·313	− ·950	− ·803	+ ·595	+ ·590	− ·830	[− ·096]	¼ set
78	x − ·525	− ·851	− ·449	+ ·893	+ ·628	− ·941	− ·124	½ set
79	x − ·496	− ·869	− ·512	+ ·859	+ ·631	− ·947	− ·124	

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Equations of Condition—continued.

80	$x-$ ·657α	$-$ ·753β	$-$ ·136γ	$+$ ·990δ	$+$ ·636y	$-$ ·958z	$=-$ ·131	
81	$x-$ ·421	$-$ ·908	$-$ ·646	$+$ ·762	$+$ ·641	$-$ ·968	$-$ ·151	½ set
82	$x-$ ·542	$-$ ·840	$-$ ·413	$+$ .910	$+$ ·666	$-$ ·999	$-$ ·128	
83	$x-$ ·579	$-$ ·815	$-$ ·327	$+$ ·945	$+$ ·685	$-$1·005	$-$ ·147	
84	$x-$ ·598	$-$ ·801	$-$ ·283	$+$ ·959	$+$ ·702	$-$1·002	$-$ ·131	
85	$x-$ ·733	$-$ ·681	$+$ ·073	$+$ ·998	$+$ ·732	$-$ ·967	$-$ ·106	½ set
86	$x-$ ·836	$-$ ·547	$+$ ·400	$+$ ·916	$+$ ·748	$-$ ·933	$-$ ·117	
87	$x-$ ·802	$-$ ·598	$+$ ·285	$+$ ·958	$+$ ·751	$-$ ·926	$-$ ·055	
88	$x+$ ·607	$+$ ·794	$-$ ·262	$+$ ·965	$+$1·132	$+$ ·944	$+$ ·111	½ set
89	$x+$ ·812	$+$ ·583	$-$ ·318	$+$ ·947	$+$1·182	$+$ ·993	[$+$ ·136]	
90	$x+$ ·889	$+$ ·457	$+$ ·581	$+$ ·812	$+$1·234	$+$ ·940	$+$ ·102	
91	$x+$ ·623	$+$ ·782	$-$ ·223	$+$ ·975	$+$1·258	$+$ ·879	$+$ ·117	
92	$x-$ ·348	$-$ ·938	$-$ ·758	$+$ ·652	$+$1·259	$+$ ·878	$+$ ·058	
93	$x-$ ·322	$-$ ·947	$-$ ·793	$+$ ·610	$+$1·270	$+$ ·844	$+$ ·035	½ set
94	$x-$ ·417	$-$ ·910	$-$ ·652	$+$ ·756	$+$1·276	$+$ ·826	$+$ ·068	
95	$x+$ ·779	$+$ ·627	$+$ ·213	$+$ ·977	$+$1·286	$+$ ·789	$+$ ·077	
96	$x-$ ·277	$-$ ·960	$-$ ·846	$+$ ·533	$+$1·287	$+$ ·786	$+$ ·053	½ set
97	$x+$ ·846	$+$ ·533	$+$ ·429	$+$ ·902	$+$1·289	$+$ ·778	$+$ ·029	½ set
98	$x+$ ·671	$+$ ·741	$-$ ·098	$+$ ·994	$+$1·308	$+$ ·698	$+$ ·103	
99	$x-$ ·695	$-$ ·719	$-$ ·035	$+$ ·999	$+$1·309	$+$ ·694	$+$ ·047	
100	$x-$ ·494	$-$ ·869	$-$ ·511	$+$ ·859	$+$1·322	$+$ ·631	$+$ ·042	
101	$x+$ ·911	$+$ ·412	$+$ ·660	$+$ ·751	$+$1·360	$+$ ·435	$+$ ·057	
102	$x-$ ·405	$-$ ·915	$-$ ·673	$+$ ·739	$+$1·360	$+$ ·432	$-$ ·003	
103	$x+$ ·884	$+$ ·466	$+$ ·565	$+$ ·824	$+$1·379	$+$ ·328	$+$ ·045	
104	$x+$ ·668	$+$ ·744	$-$ ·106	$+$ ·994	$+$1·390	$+$ ·262	$+$ ·057	
105	$x-$ ·226	$-$ ·974	$-$ ·897	$+$ ·441	$+$1·390	$+$ ·261	$+$ ·012	

In forming normals, the equations Nos. 16, 28, 29, 48, which had formerly to be rejected on account of uncertainty as to the position of the observer's head, are now retained, but equation 89 has been inadvertently rejected. Equations 8 and 15 are rejected for the same reasons as before, but 41 has been inadvertently retained with half weight. Equations 65 and 66, which depend on observations made with the prism, have been retained, on the supposition that they are free from systematic error (*i.e.* omitting the terms in α, β, γ, and δ).

Equation 77 has also been rejected on the same grounds as formerly, and

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those equations which received half weight before, also receive half weight in the formation of the following normals :—

93·00x	+ 0·15α	−12·35β	−19·39γ	+71·74δ	+32·40y	+11·43z	=+0·930
+ 0·15	+35·79	+34·93	+ 4·12	− 2·40	+ 3·29	+28·58	+3·603
−12·35	+34·93	+55·19	+ 8·70	− 5·42	− 2·11	+29·54	+4·233
−19·39	+ 4·12	+ 8·70	+27·06	−11·64	− 3·24	− 1·34	+0·143
+71·74	− 2·40	− 5·42	−11·64	+63·85	+28·29	+ 8·79	+0·815
+32·40	+ 3·29	− 2·11	− 3·24	+28·29	+37·12	+15·46	+1·482
+11·43	+28·58	+29·54	− 1·34	+ 8·79	+15·46	+51·40	+6·008

The solution of these normals, and the substitution of the values of the unknowns in the equations of condition, lead to the following results :—

	Weight.	Probable Error.	
R		R	
x =+0·00731	7·25	±·0039	
α − ·01378	7·91	±·0037	
β + ·02610	13·32	±·0029	$[p.vv] = 0·0225$
γ + ·00680	20·30	±·0023	
δ − ·00551	5·26	±·0045	$\epsilon^2 = 0·000238$
y − ·00503	20·08	±·0023	
z + ·11059	22·82	±·00218	

$$\pi = +0''·756 \pm 0''·015,$$

and the probable error of one observation $= \pm 0^{R}·0104 = \pm 0''·134$.

The representation of this solution is given in column III. (pp. 30–32).

The resulting parallax of α *Centauri* is thus practically the same for the two solutions, but the values of ϵ^2 from the two solutions, viz.—

$\epsilon^2 = 0·000185$, when the systematic errors are referred to the line joining the observer's eyes.

$\epsilon^2 = 0·000238$, when the systematic errors are referred to the angle made by the direction of measurements with the vertical.

are markedly different.

The former hypothesis is therefore the more correct. In fact, the two hypotheses involve practically so nearly the same conditions, and yet cover

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the case of all conceivable errors so completely, that we must accept as conclusive the evidence afforded by these values of ϵ^2 as to the truth of the former hypothesis.

If this conclusion is correct, the systematic errors are purely subjective, and (from the absence of similar errors in my subsequent results) appear to have been created by the influence of the neighbourhood of α_1 *Centauri* in affecting my habit of passing the image of the comparison star through that of α_2 *Centauri*.

Such errors would have been entirely eliminated by use of a reversing prism, and this conclusion is corroborated, much within the limits of probable error, by the two observations, Nos. 65 and 66, which were made with the prism.

The definitive value from the present discussion of the parallax of α *Centauri*, relative to the stars α and β, is therefore—

$$\pi = 0''.747 \pm 0''.013,$$

a result the absolute truth of which I believe to be fairly represented by the above probable error.

§ 2. *Parallax of α Centauri, 2nd Series.* Gill.

The second series of measures which I have made to determine the parallax of α *Centauri* was undertaken as a check on the principal series, discussed in § 1.

The reasons which have led to the selection of the stars of comparison employed in this series are sufficiently explained in the Introduction. The observation of such faint stars, except in the most favourable circumstances of pure sky and steady definition, is to me very trying. I cannot in other circumstances satisfy myself as to the perfection of a bisection. Some of the observations are thus unduly prolonged, and this feeling of dissatisfaction has led me, in four cases, to attach stronger notes as to the unreliability of the observations, than, from the results, it would appear that I should have done; still, I have adhered in all cases to the judgment formed at the time of observation.

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It was not my intention (nor indeed did the other work of our programme render it possible) to follow up the observations of this investigation throughout the whole year. Thus my observations were chiefly confined to epochs near two maxima and two minima of parallax. But, as the observations near the maximum of parallax were necessarily made East of the Meridian, and those near the minimum of parallax West of it, some connecting link between observations made in these two conditions was desirable, in order to determine with certainty whether the deduced parallax is affected by possible systematic error depending on the hour angle of observation.

Accordingly, observations were made in May and June 1883—in the evening East of the Meridian, and in the morning West of it,—at hour angles similar with those at which the observations near the maximum and minimum of parallax were made.

The whole series consists of 46 observations, of which 41 are employed in the computations, the other five being rejected for reasons given in the foot notes. These notes are copied from my observing journal, and record my opinion of the observations at the time; but the rejected observations appear to agree with the mean almost as well as those which have been retained.

So far as I am aware, there are no old reliable Meridian observations of the comparison stars. The following results of observations at Cordoba have been kindly communicated by Dr. GOULD. The Cape places depend on recent Meridian observations with the transit circle.

Star.	Epoch.	Mag.	Equinox 1882·0.		No. of Obs.
			α	δ	
			h m s	° ′ ″	
α' Cordoba obs. ...	1879·48	8	14 18 9·74	−60 13 6·4	3
Cape obs. ...	1882·76	8	9·55	7·0	12
β' Cordoba obs. ...	1879·22	8	14 43 52·20	−60 21 23·1	4
Cape obs. ...	1883·18	8	52·13	23·4	9

According to ELKIN's paper, quoted in § 1, we have for α_2 *Centauri*:

	h m s	° ′ ″
α_2 Centauri	14 31 35·77	−60 20 46·7
and I adopt for α'	14 18 9·60	−60 13 6·9
„ „ β'	14 43 52·15	−60 21 23·3

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whence the position angles and distances of α' and β' with respect to α_2 *Centauri* are for 1882·0—

	Position Angle.	Distance.
α'	$274^\circ 38$	$100'{\cdot}2 = 467{\cdot}2^R$
β'	$90^\circ 39$	$91'{\cdot}1 = 424{\cdot}7$

and the parallax factors for measures of the distance of α_2 *Centauri* from α' and β' are—

For α' ... ... ·9650 R cos ($\odot - 313^\circ 55$)
β' ... ... ·9510 R cos ($\odot - 130^\circ 62$)

or for

$\alpha' - \beta'$ ... ... 1·916 R cos ($\odot - 312^\circ 1$)

and for

$\alpha' + \beta'$ ... ... 0·051 R cos ($\odot - 26^\circ 2$)

The proper motion for α_2 *Centauri*, according to Elkin's data (§ 1), corresponds with its following annual variations in distance from the stars α' and β', in terms of the micrometer screw.

Epoch.	1881·0.	1882·0.	883·0.
From α'	$-0{\cdot}2527^R$	$-0{\cdot}2540^R$	$-0{\cdot}2552$
„ β'	$+0{\cdot}2447$	$+0{\cdot}2464$	$+0{\cdot}2481$

and these values have been adopted in the reductions.

The following Table contains the results of all observations made in the course of this investigation. The columns marked α' and β' give the Heliometer readings obtained in measuring the distance of α_2 *Centauri* from the stars α' and β' respectively corrected for run, refraction, proper motion, and aberration.

In correcting $\alpha' - \beta'$ for error of scale value, the sum $\alpha' + \beta'$ requires a small correction for parallax.

From a preliminary computation, I find $\pi = 0^R{\cdot}0567$, and therefore the correction to be applied to the sums of the distances is

$$-0{\cdot}0029 \,.\, R \,.\, \cos\,(\odot - 26^\circ{\cdot}2),$$

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a quantity which is quite insignificant when multiplied by

$$\frac{\alpha'-\beta'}{\alpha'+\beta'}.$$

The mean of $\alpha'+\beta'$ so corrected is

$$S_o = 891^{R}\cdot8272,$$

and the mean of $\alpha'-\beta'$ is approximately

$$D_o = 42^{R}\cdot5200,$$

and if S is any particular value of $\alpha'+\beta'$, the corresponding correction of $\alpha'-\beta'$ is

$$\Delta D = \frac{\alpha'-\beta'}{\alpha'+\beta'} = 0\cdot0477\,(S_o - S).$$

The maximum of this correction occurs in the case of observation (1), when it amounts to $-0^{R}\cdot0051$; its mean value is about $\pm0^{R}\cdot002$.

The rotation numbers of results, not employed in the after computations, are enclosed in brackets; observations which consist of "half sets" are so marked in the margin.

Measures of α_2 Centauri from Stars α^1 and β^1.

		Sidereal Time.	Images.	Steadiness.	Temperature—Fahr.	1882·0		
						α^1	β^1	$\alpha^1-\beta^1+\Delta D$
	1881 d	h m			°	R	R	R
1	July 16	16 46	2	2	57·5	467·2094	424·7256	42·4787
2	20	17 25	2	2–3	41·8	·1562	·7168	·4372
3	24	17 12	1–2	1–2	51·8	·1420	·7178	·4226
4	25	16 50	1–2	1–2	53·5	·1222	·7256	·3956
[5]	27*	18 9	4	3–4	59·0	·0763	·6591	[·4216]
6	28	17 22	2	1–2	49·9	·0939	·6490	·4489
7	29	17 7	2	2	53·8	·0862	·6816	·4074
8	Sept. 10†	18 44			57·0	·1541	·6796	[·4749]
	1882							
9	Jan. 13	10 52	1–2	2	60·5	·1765	·5493	·6316
10	19	11 12	2	2–3	62·0	·2310	·5986	·6323

* Observations made with greatest difficulty and delay. Images so blurred that accurate work was impossible.

† Stars extremely faint from haze, observations very difficult and doubtful.

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Measures of α_2 Centauri—continued.

		Sidereal Time.	Images.	Steadiness.	Temperature—Fahr.	1882·0		
						α^1	β^1	$\alpha^1-\beta^1+\Delta D$
	1882 d	h m			°	R	R	R
11	Feb. 8	11 10	2	3	65·0	467·2495	424·5970	42·6516
12	13	10 54	2–3	3	70·5	·2141	·6043	·6103
[13]	15*	9 0?			64·3			
14	16	10 48	1–2	1–2	60·0	·2360	·6002	·6354
15	22	11 46	2	2–3	51·5	·2213	·5913	·6308
16	March 2	12 2	3	3	64·0	·1973	·5791	·6207
17	4	11 33	2	2	59·3	·1898	·5731	·6199
[18]	July 27†	18 38	3	3	51·5	·1469	·7013	[·4446] ½ set
19	30	18 18			54·5	·1338	·7398	·3918
20	31	18 33	1–2	2	55·8	·1277	·7318	·3943
21	Aug. 2	18 10			55·0	·1107	·7163	·3944
[22]	5‡	17 46	2–3	3	48·0			
23	7	18 17	2–3	2–3	55·0	·1033	·6976	·4069
24	11	18 2	2	2	52·3	·1283	·7093	·4185
25	12	18 20	1–2	1–2	52·5	·1083	·7006	·4085
26	14	18 3	1	1–2	52·9	·0959	·6944	·4032
27	16	18 24	1–2	1–2	52·0	·1096	·7076	·4024
	1883							
28	Feb. 13	9 44	2	2–3	64·0	·2394	·6144	·6238
29	14	9 30	2	2–3	63·5	·2470	·5967	·6496
30	28	10 54			63·3	·2216	·5956	·6266
31	March 1	10 41	2–3	2–3	64·5	·1834	·6253	·5591
32	3	10 59	2	2	66·0	·2189	·6148	·6039 ½ set
33	6	11 20			65·0	·1983	·6059	·5936
34	May 28	17 51	1–2	1–2	57 0	·1589	·6855	·4727
35	29	17 25	1–2	1–2	52·0	·1595	·6782	·4809 ½ set
36	30	11 1	2	2	56·5	·1664	·6870	·4783
37	30	17 54	2	2	55·0	·1630	·6610	·5023
38	June 4	11 15	2	2	49·8	·1636	·6991	·4629
39	10	11 19	2	2	52·5	·1384	·6790	·4599
40	10	18 33	2–3	2–3	42·3	·1569	·6869	·4691
41	13	11 36	1	2	45·8	·1463	·7010	·4444
42	13	18 21	1	1–2	37·5	·1599	·7248	·4324
43	18	11 45	1–2	2–3	48 5	·1275	·6891	·4490
44	19	11 53	1–2	2	51·5	·1523	·6949	·4565
45	19	18 1	2	2	52·3	·1537	·7223	·4291
46	20	18 19	2	2	55·0	·1410	·6990	·4415

* Star extremely faint from haze; also some ambiguity as to the hour. This set useless.

† Very difficult because of haze; last bisection extremely unsatisfactory, and could not be repeated because of increased haze.

‡ Measures made with focal point displaced 1 mm.; discovered at end; not to be used.

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		R
Putting the mean value of $\alpha'-\beta'$ for 1882·0	=	$42^{s}\cdot5200+x$
„ correction of the assumed annual variation of $\alpha'-\beta'$	=	y
and $1\cdot916\pi$	=	z

we obtain the equations of condition given in the following Table.

The columns marked I., II., and III. contain the residuals from their different solutions, and are afterwards more fully explained. The column marked p indicates those equations which result from a "half set" of observations, and which therefore obtain half weight in the formation of the normal equations.

In the following equations:

x_E indicates that the equations depend on observations made East of the Meridian.
x_W that it depends on observations made West of the Meridian.

also, since there is still some uncertainty as to the relative masses and orbital motion of α_1 and α_2 *Centauri*, the term y', whose coefficient is the square of the time in years from 1882·0, has been introduced.

Equations of Condition.

Group			I.	II.	III.	p
		R				
I.	1	$x_W - 0\cdot462y + 0\cdot213y' - 0\cdot968z = -\cdot041$	+·047	[+·060]	[+·052]	
	2	$x_W - \cdot451 + \cdot203 - \cdot986 - \cdot083$	+ 7	+ 20	+ 12	
	3	$x_W - \cdot440 + \cdot194 - 1\cdot000 - \cdot097$	− 5	+ 8	0	
	4	$x_W - \cdot438 + \cdot192 - 1\cdot003 - \cdot124$	− 31	− 19	− 27	
	6	$x_W - \cdot429 + \cdot184 - 1\cdot009 - \cdot071$	+ 23	+ 35	+ 27	
	7	$x_W - \cdot427 + \cdot182 - 1\cdot011 - \cdot113$	− 19	− 7	− 14	
II.	9	$x_E + \cdot034 + \cdot001 + 0\cdot934 + \cdot112$	− 3	+ 1	+ 1	
	10	$x_E + \cdot051 + \cdot003 + \cdot962 + \cdot112$	− 6	− 2	− 2	
	11	$x_E + \cdot106 + \cdot011 + \cdot977 + \cdot132$	+ 14	+ 17	− 1	
	12	$x_E + \cdot119 + \cdot014 + \cdot966 + \cdot090$	− 27	− 24	− 23	
	14	$x_E + \cdot127 + \cdot016 + \cdot954 + \cdot115$	0	+ 2	+ 4	
	15	$x_E + \cdot144 + \cdot021 + \cdot923 + \cdot111$	0	+ 2	+ 3	
	16	$x_E + \cdot166 + \cdot028 + \cdot857 + \cdot101$	− 2	− 1	+ 1	
	17	$x_E + \cdot171 + \cdot029 + \cdot840 + \cdot100$	− 1	0	+ 2	

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Equations of Condition—continued.

Group			I.	II.	III.	*p*
III.	19	$x_W + ·576y + ·332y' - 1·012z = R - ·128$	− 13	− 19	− 10	
	20	$x_W + ·579 + ·335 - 1·013 - ·126$	− 10	− 17	− 8	
	21	$x_W + ·584 + ·341 - 1·014 - ·126$	− 10	− 17	− 8	
	23	$x_W + ·598 + ·358 - 1·012 - ·113$	+ 3	− 4	+ 5	
	24	$x_W + ·609 + ·371 - 1·006 - ·102$	+ 14	+ 6	+ 16	
	25	$x_W + ·612 + ·375 - 1·004 - ·112$	+ 3	− 4	+ 5	
	26	$x_W + ·616 + ·379 - 0·998 - ·117$	− 2	− 9	− 1	
	27	$x_W + ·622 + ·387 - 0·991 - ·118$	− 4	− 11	− 2	
IV.	28	$x_E + 1·119 + 1·252 + ·963 + ·104$	+ 9	− 7	− 7	
	29	$x_E + 1·122 + 1·259 + ·959 + ·130$	+ 36	+ 20	+ 19	
	30	$x_E + 1·160 + 1·346 + ·875 + ·107$	+ 23	+ 6	+ 5	
	31	$x_E + 1·163 + 1·353 + ·867 + ·039$	− 44	[− 61]	[− 62]	
	32	$x_E + 1·168 + 1·364 + ·850 + ·084$	+ 3	− 14	− 15	½
	33	$x_E + 1·177 + 1·385 + ·823 + ·074$	− 4	− 21	− 22	
V_W.	34	$x_W + 1·404 + 1·971 - ·432 - ·047$	[+ 21]	+ 1	− 4	
	35	$x_W + 1·407 + 1·980 - ·448 - ·039$	[+ 31]	+ 11	+ 5	½
	37	$x_W + 1·409 + 1·985 - ·464 - ·018$	[+ 54]	+ 33	+ 28	
	40	$x_W + 1·440 + 2·074 - ·620 - ·051$	[+ 39]	+ 18	+ 12	
	42	$x_W + 1·448 + 2·097 - ·660 - ·088$	[+ 7]	− 15	− 20	
	45	$x_W + 1·464 + 2·143 - ·734 - ·091$	[+ 12]	− 10	− 15	
	46	$x_W + 1·467 + 2·152 - ·744 - ·079$	[+ 25]	+ 3	− 2	
V_E.	36	$x_E + 1·408 + 1·982 - ·459 - ·042$	[+ 29]	+ 5	+ 3	
	38	$x_E + 1·422 + 2·022 - ·533 - ·057$	[+ 23]	− 2	− 3	
	39	$x_E + 1·439 + 2·071 - ·617 - ·060$	[+ 30]	+ 4	+ 3	
	41	$x_E + 1·447 + 2·094 - ·656 - ·076$	[+ 18]	− 8	− 9	
	43	$x_E + 1·461 + 2·135 - ·717 - ·071$	[+ 30]	+ 4	+ 3	
	44	$x_E + 1·464 + 2·143 - ·731 - ·064$	[+ 39]	+ 13	+ 11	

The equations of condition are divided into groups, the mean of each of which should be satisfied, within certain limits, by any complete solution of the whole.

Groups I. and III. depend on observations made near the minimum of parallax, all of necessity West of the Meridian.

Groups II. and IV. depend on observations made near the parallax maximum, and East of the Meridian.

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Group V. contains the equations which depend on observations made East and West of the Meridian, for the special purpose of determining the existence, or otherwise, of systematic errors in the different circumstances under which the observations at maximum and minimum parallax were made. The group is accordingly arranged in two sub-groups marked V_W. and V_E., which depend on nearly simultaneous observations.

It will be convenient to find the normal equations separately.

1st for the Groups I. II. III. and IV.
2nd for the Group V.

Giving half weight to the equations 32 and 35, which depend on "half sets" of observations, the following are the resulting normals :—

From Groups I. II. III. and IV.

$+13{\cdot}50x_E$		$+\ 7{\cdot}24y$	$+\ 7{\cdot}40y'$	$+12{\cdot}33z$	$=+1{\cdot}369$
	$+14{\cdot}00x_W$	$+\ 2{\cdot}15$	$+\ 4{\cdot}05$	$-14{\cdot}03$	$-1{\cdot}471$
$+\ 7{\cdot}24$	$+\ 2{\cdot}15$	$+11{\cdot}45$	$+\ 9{\cdot}60$	$+\ 4{\cdot}29$	$+0{\cdot}335$
$+\ 7{\cdot}40$	$+\ 4{\cdot}05$	$+\ 9{\cdot}60$	$+10{\cdot}91$	$+\ 2{\cdot}54$	$+0{\cdot}224$
$+12{\cdot}33$	$-14{\cdot}03$	$+\ 4{\cdot}29$	$+\ 2{\cdot}54$	$+25{\cdot}35$	$+2{\cdot}737$

From Group V.

$+\ 6{\cdot}00x_E$		$+\ 8{\cdot}64y$	$+12{\cdot}45y'$	$-\ 3{\cdot}71z$	$=-0{\cdot}370$
	$+\ 6{\cdot}50x_W$	$+\ 9{\cdot}34$	$+13{\cdot}41$	$-\ 3{\cdot}88$	$-0{\cdot}394$
$+\ 8{\cdot}64$	$+\ 9{\cdot}34$	$+25{\cdot}86$	$+37{\cdot}21$	$-10{\cdot}95$	$-1{\cdot}103$
$+12{\cdot}45$	$+13{\cdot}41$	$+37{\cdot}21$	$+53{\cdot}55$	$-15{\cdot}80$	$-1{\cdot}594$
$-\ 3{\cdot}71$	$-\ 3{\cdot}88$	$-10{\cdot}95$	$-15{\cdot}80$	$+\ 4{\cdot}77$	$+0{\cdot}487$

Taking for preliminary solution the normals from Groups I., II., III., and IV. only, and writing $x=x_E=x_W$ (since x_E-x_W cannot be determined from them), and solving for x, y, and z in terms of y' we obtain—

$[p.vv]=0{\cdot}009575$ $\quad\quad$ $\epsilon^2=0{\cdot}000383$

$x=+0{\cdot}0106^R$	$-0{\cdot}179y'^R$,	Weight 18·65,	Probable error	$\pm 0{\cdot}0030^R$
$y\ -0{\cdot}0215$	$-0{\cdot}693$	„ 7·30	„	„ $\pm$ ·0048
$z\ +0{\cdot}1124$	$+0{\cdot}005$	„ 22·36	„	„ $\pm$ ·0027

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whence

$$\pi = 0''.755 + 0.003y' \pm 0''.018$$

and the probable error of one observation $= \pm 0^{R}.0129 = \pm 0''.166$.

Here we obtain a value of π, which is practically independent of the value of y', but which entirely rests upon an assumed freedom of the observations from systematic error depending on the hour angle. The representation of this solution (omitting terms in y') is given in Column I., adjoining the equations, and the substitution is continued in Group V. for the purpose of comparison. A glance is enough to show that Group V. is not at all represented in this way. There has either been some change in my habit of observing, or the error of the adopted proper motion of α_2 *Centauri* along the line of these measures cannot be represented by a term proportional to the time. There are two discordant observations, Nos. 1 and 31, which are rejected by Peirce's Criterion, and which, on examination of the original observations, show unusual discordances in the separate bisections. It seems reasonable, before further considering one or other of the above suggested hypotheses, to reject these two discordant observations, and to make a second solution including all the remaining observations, but finding the values of x_E, x_W, y and z in terms of y'.

When equations 1 and 31 are rejected, the normals from the remaining equations of Groups I., II., III. and IV. become

$+12.50x_E$		$+6.08y$	$+6.05y'$	$+11.46z$	$=+1.330$
	$+13.00x_W$	$+2.61$	$+3.83$	-13.06	-1.430
$+6.08$	$+2.61$	$+9.88$	$+8.13$	$+2.84$	$+0.271$
$+6.05$	$+3.83$	$+8.13$	$+9.04$	$+1.57$	$+0.180$
$+11.46$	-13.06	$+2.84$	$+1.57$	$+23.66$	$+2.663$

When these are added to the corresponding normals from Group V., the solution of the new normals so formed, and the substitution of the resulting values of x_E, x_W, y and z in the original equations, lead to the following:—

$[p.vv] = 0.007494$ $\quad \epsilon^2 = 0.000214$

$x_E = {}^{R}+0.0082 - 0.191y'$,	Weight	7.68,	Probable error	$\pm {}^{R}0.0036$
x_W $+ .0039 + .028$	„	7.76	„	„	$\pm .0035$
y $- .0030 - 1.144$	„	15.26	„	„	$\pm .0025$
z $+ .1099 + 0.244$	„	9.56	„	„	$\pm .0032$

and

$$\pi = 0''.738 + 0.127y \pm 0''.021.$$

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The representation of this solution is given in Column II. ; but, for the following reasons, it is not a satisfactory one.

If we take the normals in x_E and x_W from Group V., we get from them nearly equal values for x_E and x_W whatever values (within reasonable limits) of y, y' and z are substituted.* Solution II. disturbs this equality, and gives the whole of the residuals of Group III., with one small exception, the negative sign. I have, therefore, made another solution in which x_E is assumed $=x_W=x$ and including y' as unknown.

We then obtain

$$[p.vv]=0\cdot005757 \qquad \epsilon^2=0\cdot000164$$

$x=+0^R\cdot0047$,	Weight 17·27,	Probable error	$\pm 0^R\cdot0021$
$y \quad -\ \cdot0217$	„ 2·66	„	„ $\pm\ \cdot0053$
$y' \quad +\ \cdot0165$	„ 4·37	„	„ $\pm\ \cdot0041$
$z \quad +\ \cdot1144$	„ 23·37	„	„ $\pm\ \cdot0018$

$$\pi = 0''\cdot768 \pm 0''\cdot012$$

and the probable error of one observation $=\pm 0^R\cdot00865=\pm 0''\cdot111$.

The representation of this solution is given in Column III. The following Table gives the mean representation of each group of equations according to the three preceding solutions:—

	I.	II.	III.	IV.	V.$_W$	V.$_E$
	R	R	R	R	R	R
Solution I. ...	+·0037	−·0030	−·0024	+·0038	[+·0270]	[+·0282]
„ II. ...	+ 74	− 6	− 94	− 32	+ 60	+ 27
„ III. ...	− 4	− 19	− 4	− 40	+ 4	+ 13

The last solution alone satisfies all the groups within limits of probable error; there seems, therefore, strong evidence in favour of the reality of a

* The substitution of the values of y and z from Solution I. in the normals for x_E and x_W from Group V. gives—

$$x_E-x_W=+0^R\cdot0014=0''\cdot018$$

a quantity which would change the resulting parallax by only $+0''\cdot005$.

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term depending on the square of the time. If we accept the evidence of the present solution, and the collateral evidence afforded by the after discussion of my observations of *Sirius*, ϵ *Indi*, and *Lacaille* 9352, to show that my measures of single stars are not affected by systematic error depending on the hour angle of observation, and also regard the term depending on the square of the time as admissible, we obtain as above—

$$\pi = 0''.768 \pm 0''.012.$$

If in this solution the rejected observations 1 and 31 are retained, we find

$$\pi = 0''.748 \pm 0''.016,$$

and the residuals for these equations become $-^{R}.053$ and $+^{R}.041$ respectively.

If we reject only equation 31 we obtain

$$\pi = 0''.763 \pm 0''.014,$$

and the residual for equation 1 becomes $+^{R}.042$.

Both equations 1 and 31 are very markedly discordant, and we cannot be far in error, if we grant the question of freedom from systematic error, to adopt

$$\pi = 0''.76 \pm 0''.013.$$

If freedom from systematic error depending upon the hour angle of observation is to be estimated solely from the internal evidence furnished by the observations of this series alone, then we must modify very considerably the estimate of probable error, the weight of z becoming 9·56 instead of 23·37. For this case we may, with sufficient accuracy, take Solution II. and substitute the value of y' found from Solution III., when we obtain

$$\pi = 0''.765 \pm 0''.021.$$

If we attempt to force a simultaneous solution of the whole of the equations, omitting y' on the ground that it is an inadmissible term, we get all the residuals of Group II., excepting No. 12, with residuals of + sign, and the whole of Group III. with negative residuals. Unless, therefore, my habit of bisecting α_2 *Centauri* has changed during the period over which the

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observations extend, the solution without y' is inadmissible. I may here state that during the whole series I have never been able to see α_1 during the bisection of α_2 *Centauri*, so effectually was the former star obliterated by the screen. I could only glimpse α_1 by special effort in a dark field, and I have always made the bisections of α_2 *Centauri* with a slightly illuminated field. Under such circumstances it is difficult to understand why my habit of bisecting α_2 *Centauri* should have been different from that of any other star of like apparent magnitude, and there is abundant evidence that no change in my habit of observing occurred during the same period in the other series of observations. On the other hand, so large a value of y' cannot be reconciled with the results of Meridian observations, and with an orbit representing our Heliometer observations of α *Centauri* as a double star. The ultimate test as to which of the two hypotheses is to be accepted is to wait till, in the course of time, further observations have determined the orbit and relative masses of α_1 and α_2 *Centauri* with more accuracy.

Meanwhile it is well to note, that if we take Groups I., II., III. and IV. to determine the parallax in terms of $x_E - x_W$, and determine $x_E - x_W$ from Group V., the resulting parallax is practically the same, whether we introduce the term y' or not.

We obtain

$$\pi = 0''.74$$

if we retain all the observations ; or if we reject the outstanding equations 1 and 31 we obtain

$$\pi = 0''.765 \text{ or } 0''.768.$$

The probabilities are in favour of the latter solution, and we cannot be far in error if we adopt as the result of this series of observations—

$$\pi = 0''.76 \pm \begin{cases} 0''.013 \\ 0''.021 \end{cases}$$

where the upper value of the probable error is to be adopted if we take collateral as well as direct evidence of the freedom of the observations from systematic error, and the lower if we determine freedom from such error by the evidence of this series of observations alone.

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§ 3. *Parallax of α Centauri.* ELKIN.

As soon as the Heliometer was brought into good working order and our programme settled, I commenced the observation of α_2 *Centauri*, the brighter component of the pair, and the comparison stars *a* and *b*. On the whole this pair could not be considered unfavourable. Besides some advantages which will appear later on, the stars were fairly symmetrically situated with respect to α_2 *Centauri*, the distances being about in the ratio 4 to 5, and the position angles of the lines α_2 *Centauri-a* and α_2 *Centauri-b* differing but about 6° from 180°, as will be seen from their approximate values :—

Star.	Magnitude.	Distance.	Position Angle.
		R	° ′
a	6·9	484·2 (=104′·1)	354 16
b	7½	386·6 (= 83′·1)	168 27
	Difference ...	97·6	185 49

On the other hand, the factor of parallax is but about ¾ of its maximum value, amounting to

$$1{\cdot}580 \,.\, \mathrm{R} \,.\, \sin\,(\odot + 76°{\cdot}8)$$

for the *difference* of the two distances. The inequality of magnitude of the two comparison stars is not very great, but still it is sufficient to render the observation of the two stars somewhat different. The star *a* is called 6·9 in the *Uranometria Argentina*, and the screen used, the same as for GILL's brighter pair, reduced α_2 *Centauri* to but a trifle less brilliancy—say 7·0 magnitude—whereas the star *b* was a full half-magnitude fainter. It certainly would have been better to have brought α_2 *Centauri* nearer midway in brightness between the two comparison stars; but I may confess, in the beginning

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of our work, this point escaped my attention. However, the star *b* was still quite bright enough to be seen as a sharply-defined elongated disc, and to be brought into close juxtaposition with α_2 *Centauri*, the separate bisections being at least as accurate as those of the other star, so that I am of the opinion that whatever systematic error may be found in the work, but little of it can be due to this cause.

The series extends from March 7, 1881, to May 29, 1882, without any serious break. There are in all 92 observations, of which 87 are available for the determination of the parallax. The remaining 5 were made under such unfavourable atmospheric circumstances as to make it unwise to include them; the "Images" were noted at the time as 3–4, and it is not unlikely that when the diffusion is so great as this figure would imply, the companion might exert an undue influence on the measures. As a matter of fact I may mention that these observations do show a tendency to err in the direction of the companion.

The Table which follows contains the result of these observations. The distances are corrected for refraction, screw error, and run; for aberration by the formulæ—

			R
α *Centauri-a*	...	...	$+0''.0280 \sin (\odot + 121°.5)$
α *Centauri-b*	...	...	$+0''.0358 \sin (\odot + 122°.4)$

and they are already reduced to 1882·0. For this reduction the proper motion of α_2 *Centauri* has been taken as in GILL's paper, § 1; resolved in the directions of the comparison stars I find for the annual motion in semi-revolutions—

			α_2 *Centauri-a.*	α_2 *Centauri-b.*
			R	R
1881·0	...	...	−0·1487	+0·1713
1882·0	...	...	0·1430	0·1658
1883·0	...	...	0·1373	0·1604

and these values have been used in the reductions.

The material for estimating the proper motions of the comparison stars is as follows, the positions being brought up to 1880·0:—

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Star a (*Lacaille* 5997).

	h	m	s	°	′	″
Lacaille 1750	14	30	8·7	−58	36	45
Brisbane 1825			7·5			46·1
Taylor 1835			7·58			51·2
Gould 1874			6·62			55·7
Stone 1880			6·46			55·2
Cape 1882			6·20			56·7

Star b (*Lacaille* 6023).

	h	m	s	°	′	″
Lacaille 1750	14	33	45·8	−60	40	57
Brisbane 1825			42·6		41	29·4
Gould 1876			43·38		41	29·9
Stone 1880			43·15		41	28·7
Cape 1882			43·37		41	29·5

I have made no attempt to determine any systematic correction for *Lacaille* and *Brisbane*, and only applied $+2^{s}\cdot2$ to the Right Ascensions of the latter catalogue (see p. 273 of the work). For TAYLOR I find from the 37 stars of 14^{h} Right Ascension between $-55°$ and $-65°$ of Declination that the places in the *General Catalogue* require the corrections

$$-0^{s}\cdot56 \quad \text{and} \quad -0''\cdot8$$

to reduce them to STONE, which have been accordingly applied. It seems not improbable that the star *a* has small negative motions in both co-ordinates, if they be taken

$$-0^{s}\cdot025 \quad \text{and} \quad -0''\cdot10,$$

the effect on the distance *a Centauri-a* is

$$-0^{R}\cdot0062.$$

For star *b* nothing can be inferred, beyond that the motions are very small.

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Observations.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	α Cent.-*a*.	α Cent.-*b*.
	1881.	h m			°	R	R
1	Mar. 7	9 15	(2)	(2)	69·9	484·339	386·758
2	11	11 33	2	2	70·7	·191	·650
3	17	9 34	2	3	60·4	·161	·581
4	19	10 20	1	2–3	59·6	·160	·591
5	22	11 48	3–4	3	59·6	·233	·600
6	24	11 18	2–3	2–3	59·8	·151	·597
7	25	10 23	2	2–3	65·1	·155	·584
8	30	11 3	1–2	2	58·4	·174	·593
9	April 6	11 12	1	2	61·8	·166	·621
10	7	10 22	2	2	57·4	·156	·607
11	10	10 26	2	2	54·9	·186	·597
12	12	10 58	2	3–4	54·9	·142	·597
13	20	10 35	1	2	57·0	·260	·671
14	22	11 20	2–3	2	59·0	·250	·639
15	23	11 16	2–3	2–3	68·5	·244	·638
16	May 4	12 20	3	3	56·6	·217	·673
17	20	13 57	3	3	54·5	·194	·647
18	23	10 38	2–3	3	51·8	·188	·660
19	June 13	12 12	3	2–3	58·5	·181	·692
20	16	12 20	3–4	3	54·9	·179	·657
21	17	14 14	3–4	3	63·3	·211	·655
22	21	16 38	2	3	57·5	·135	·693
23	22	12 35	2	2	54·9	·151	·696
24	July 1	16 2	2	3	46·6	·207	·729
25	2	15 53	2	3	42·9	·183	·747
26	6	17 46	3–4	3	56·8	·182	·718
27	8	16 4	2	2–3	50·0	·182	·731
28	10	16 36	2	2–3	49·2	·155	·695
29	12	16 24	2	2–3	43·6	·186	·686
30	13	16 35	2–3	3	47·6	·180	·716
31	18	18 21	2–3	2–3	39·8	·176	·687
32	Aug. 8	18 48	2	2	53·5	·109	·666 ¾ set

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Observations—continued.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	α Cent.-*a*.	α Cent.-*b*.
	1881.	h m			°	R	R
33	Aug. 12	17 25	2	2	47·9	484·116	386·678
34	13	19 9	1–2	2	51·5	·121	·582
35	16	18 20	1–2	1–2	55·8	·111	·661
36	19	18 54	2–3	3	56·3	·097	·678
37	25	18 57	2	2	45·0	·113	·680
38	27	18 49	2–3	2–3	54·0	·096	·663
39	29	19 40	2	2	56·0	·087	·670
40	Sept. 3	20 8	2	2	44·5	·095	·702
41	6	19 9	1–2	2	48·7	·104	·700
42	9	19 50	3–4	3	72·2	·088	·674
43	10	20 19	3	2–3	55·2	·107	·654
44	14	19 36	2	2	53·2	·089	·689
45	22	19 48	2–3	2	58·5	·128	·693
46	26	20 47	1–2	2–3	51·2	·110	·721
47	30	19 45	2–3	2–3	60·0	·099	·670
48	Oct. 4	21 24	2–3	2–3	58·6	·108	·678
49	6	20 19	1–2	2	56·0	·091	·656
50	10	20 51	1–2	2–3	50·0	·095	·684
51	19	21 19	2–3	2–3	58·2	·153	·701
52	24	21 59	2–3	2–3	54·5	·138	·690
53	31	22 6	2–3	2–3	52·0	·104	·666
54	Nov. 13	7 23	3	3	47·7	·069	·689
55	18	7 30	2	2–3	51·2	·079	·670
56	25	8 8	2–3	3–4	59·5	·024	·665
57	28	8 10	1–2	2–3	47·7	·150	·750
58	Dec. 4	8 32	2	2	60·5	·106	·702
59	9	7 37	2	2–3	60·0	·154	·721
60	23	9 27	1	2	53·5	·106	·654
61	25	7 46	2	2	59·0	·122	·659
	1882						
62	Jan. 17	8 18	2–3	2–3	67·0	·123	·628
63	18	8 44	2–3	2–3	62·5	·108	·636
64	21	7 42	2	2–3	65·0	·124	·641

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Observations—continued.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	α Cent.-*a*.	α Cent.-*b*.
	1882.	h m			°	R	R
65	Feb. 3	8 28	2	2–3	56·0	484·115	386·617
66	14	8 16	1–2	2–3	67·0	·125	·610
67	Mar. 3	10 46	2–3	2–3	60·0	·120	·591 $\frac{7}{8}$ set
68	4	8 46	2	2–3	60·0	·123	·585
69	5	11 40	1–2	1	65·0	·115	·602
70	6	8 39	2–3	2–3	60·0	·126	·573
71	17	11 14	1	2	60·5	·174	·603
72	23	12 27	2	2	63·0	·180	·639
73	24	11 47	1–2	2	59·0	·169	·610
74	April 8	18 14	1–2	2	51·5	·204	·598
75	11	11 17	1–2	1–2	56·5	·169	·603 $\frac{5}{8}$ set
76	12	13 3	2	2–3	62·5	·159	·629
77	21	13 41	1–2	2	53·0	·158	·614
78	22	12 8	2–3	3–4	57·0	·134	·588
79	25	13 41	1–2	2	57·0	·151	·605
80	May 4	19 8	2–3	2–3	57·2	·177	·565
81	6	17 57	2	2–3	51·5	·164	·596
82	11	20 2	2–3	2–3	54·0	·163	·603
83	18	17 54	2	2–3	50·5	·145	·586
84	19	17 6	2	2–3	49·5	·159	·595
85	20	11 45	2	2	55·0	·120	·590 $\frac{1}{2}$ set
86	21	11 48	2–3	2–3	54·7	·134	·603
87	22	11 42	1–2	2–3	51·7	·139	·605
88	22	18 18	2	2–3	45·5	·135	·588
89	24	10 22	2	2–3	57·0	·138	·581
90	25	10 23	2–3	2–3	59·0	·118	·598
91	25	19 44	2	2	50·0	·121	·588
92	29	17 45	2	2	49·0	·133	·583

As has been already said, we do not propose to discuss the *sums* of the two distances, but only to use them for the deduction of the instantaneous scale-value with which to reduce the *differences* of the two distances. The

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stars being not quite exactly opposite one another, a small fraction of the parallax enters into these *sums*, and before using them I have applied the small correction

$$-0\cdot092 \sin (\odot + 326^{\circ}\cdot4) \cdot \pi,$$

assuming from a first discussion

$$\pi = {}^{R}0\cdot060.$$

The mean of all these *sums*, except the first one, for which the focal scale reading was not noted, is

$$870\cdot790,$$

and the separate deviations from this value are supposed to be due entirely to changes of the scale value. Treating these deviations as residuals would give for the probable error of a *sum* about

$$\pm {}^{R}0\cdot031 = 0''\cdot40;$$

it will be seen that the probable error of an average measure of a *difference* is about $\pm 0''\cdot17$, so that it is obvious that by far the greater portion of the deviations are really due to change of the scale value. The correction of an observed *difference* is therefore

$$-(\text{Observed sum} - 870\cdot790)\,\frac{97\cdot5}{870\cdot8}.$$

This correction amounts to

$${}^{R}0\cdot035 = 0''\cdot45$$

for the first observation, for which the focal scale reading is not known, otherwise its maximum value is

$${}^{R}0\cdot016 = 0''\cdot21.$$

The equations of condition which these *differences* then give rise to are contained in the following Table, x denoting the correction to the mean difference, assumed to be

$${}^{R}97\cdot500;$$

y is for sake of convenience taken $= 1\cdot580\ \pi$, π being the parallax of the central star, and z is a term proportional to the time, or a correction to the assumed annual variation of the difference.

The columns "Residuals," "Weight," and "Position" will be referred to and explained later on.

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Equations of Condition.

No.					Residuals. I.	Residuals. II.	Residuals. III.	Weight.	Position.
				R	R	R	R		
1	$+1.0x$	$+0.894y$	$-0.817z$	$=+0.046$	−0·005	−0·012	−0·012	1·0	E
2	1·0	+0·922	−0·806	+0·035	−0·018	−0·025	−0·025	1·0	E
3	1·0	+0·958	−0·790	+0·085	+0·029	+0·022	+0·019	0·9	E
4	1·0	+0·967	−0·784	+0·073	+0·016	+0·009	+0·005	1·2	E
5	1·0	+0·978	−0·776	+0·128	[+0·070]	[+0·063]			E
6	1·0	+0·986	−0·771	+0·058	0·000	−0·008	−0·010	1·0	E
7	1·0	+0·988	−0·768	+0·076	+0·018	+0·010	+0·006	1·0	E
8	1·0	+0·998	−0·754	+0·083	+0·024	+0·016	+0·013	1·2	E
9	1·0	+0·999	−0·735	+0·046	−0·013	−0·021	−0·023	1·3	E
10	1·0	+0·998	−0·732	+0·052	−0·007	−0·015	−0·018	1·0	E
11	1·0	+0·993	−0·724	+0·090	+0·032	+0·023	+0·020	1·0	E
12	1·0	+0·987	−0·718	+0·051	−0·007	−0·015	−0·018	0·8	E
13	1·0	+0·958	−0·697	+0·073	+0·017	+0·010	+0·006	1·3	E
14	1·0	+0·948	−0·691	+0·100	+0·045	+0·038	+0·036	1·0	E
15	1·0	+0·942	−0·688	+0·096	+0·042	+0·035	+0·032	1·0	E
16	1·0	+0·863	−0·658	+0·033	−0·016	+0·001		0·8	EM
17	1·0	+0·695	−0·615	+0·041	+0·006	+0·023		0·8	M
18	1·0	+0·660	−0·606	+0·022	−0·011	−0·011	−0·015	0·9	E
19	1·0	+0·353	−0·549	−0·020	−0·028	−0·001		0·9	EM
20	1·0	+0·307	−0·540	+0·017	[+0·012]	[+0·040]			EM
21	1·0	+0·291	−0·538	+0·047	[+0·044]	[+0·069]			M
22	1·0	+0·224	−0·527	−0·062	−0·060	−0·043		0·9	MW
23	1·0	+0·208	−0·524	−0·051	−0·048	−0·018		1·0	EM
24	1·0	+0·057	−0·500	−0·038	−0·023	+0·006		0·9	MW
25	1·0	+0·041	−0·497	−0·079	−0·062	−0·033		0·9	M
26	1·0	−0·028	−0·486	−0·047	[−0·025]	[−0·054]			W
27	1·0	−0·062	−0·480	−0·062	−0·038	−0·015		1·0	MW
28	1·0	−0·096	−0·475	−0·046	−0·019	+0·004		1·0	MW
29	1·0	−0·129	−0·469	−0·007	+0·022	+0·047		1·0	MW
30	1·0	−0·146	−0·467	−0·047	−0·016	+0·008		0·9	MW
31	1·0	−0·229	−0·453	−0·019	+0·018	−0·007	+0·001	1·0	W
32	1·0	−0·554	−0·396	−0·056	+0·007	−0·011	−0·005	1·0	W
33	1·0	−0·609	−0·385	−0·062	+0·006	−0·012	−0·006	1·0	W
34	1·0	−0·623	−0·382	−0·062	+0·007	−0·010	−0·005	1·1	W
35	1·0	−0·661	−0·374	−0·049	+0·023	+0·006	+0·013	1·2	W
36	1·0	−0·699	−0·366	−0·080	−0·005	−0·021	−0·015	0·9	W
37	1·0	−0·768	−0·350	−0·067	+0·013	−0·001	+0·005	1·0	W
38	1·0	−0·789	−0·344	−0·063	+0·019	+0·005	+0·011	1·0	W
39	1·0	−0·810	−0·338	−0·079	+0·005	−0·009	−0·006	1·0	W

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Equations of Condition—continued.

No.					Residuals.			Weight.	Position.
					I.	II.	III.		
				R	R	R	R		
40	$+1.0x$	$-0.845y$	$-0.332z =$	-0.107	-0.021	-0.034	-0.034	1·0	W
41	1·0	−0·881	−0·316	−0·097	−0·008	−0·020	−0·014	1·1	W
42	1·0	−0·905	−0·308	−0·082	[+0·009]	[−0·003]			W
43	1·0	−0·911	−0·305	−0·043	+0·049	+0·037	+0·035	0·9	W
44	1·0	−0·938	−0·294	−0·098	−0·004	−0·015	−0·013	1·0	W
45	1·0	−0·976	−0·272	−0·068	+0·028	+0·018	+0·020	1·0	W
46	1·0	−0·987	−0·261	−0·115	−0·017	−0·028	−0·035	1·1	W
47	1·0	−0·996	−0·250	−0·068	+0·030	+0·021	+0·022	1·0	W
48	1·0	−1·000	−0·239	−0·069	+0·029	+0·020	+0·005	1·0	W
49	1·0	−0·999	−0·234	−0·060	+0·038	+0·029	+0·026	1·1	W
50	1·0	−0·996	−0·223	−0·088	+0·010	+0·001	−0·007	1·1	W
51	1·0	−0·968	−0·198	−0·055	+0·040	+0·031	+0·018	1·0	W
52	1·0	−0·944	−0·185	−0·056	+0·039	+0·028	+0·004	1·0	W
53	1·0	−0·897	−0·166	−0·060	+0·030	+0·019	−0·006	1·0	W
54	1·0	−0·771	−0·129	−0·117	−0·038	−0·009	+0·002	0·8	E
55	1·0	−0·714	−0·116	−0·087	−0·012	+0·015	+0·026	1·0	E
56	1·0	−0·624	−0·097	−0·130	−0·062	−0·036	−0·031	0·8	E
57	1·0	−0·583	−0·088	−0·113	−0·049	−0·024	−0·019	1·1	E
58	1·0	−0·495	−0·072	−0·098	−0·041	−0·016	−0·015	1·0	E
59	1·0	−0·414	−0·058	−0·077	−0·027	−0·003	+0·006	1·0	E
60	1·0	−0·185	−0·020	−0·045	−0·013	+0·007	+0·002	1·3	E
61	1·0	−0·150	−0·014	−0·037	−0·008	+0·012	+0·018	1·0	E
62	1·0	+0·248	+0·049	−0·001	−0·004	+0·009	+0·011	1·0	E
63	1·0	+0·265	+0·051	−0·023	−0·027	−0·015	−0·015	1·0	E
64	1·0	+0·316	+0·060	−0·015	−0·023	−0·012	−0·003	1·0	E
65	1·0	+0·521	+0·095	+0·003	−0·019	−0·013	−0·011	1·0	E
66	1·0	+0·673	+0·125	+0·021	−0·007	−0·009	−0·005	1·1	E
67	1·0	+0·860	+0·171	+0·037	−0·016	−0·012	−0·017	1·0	E
68	1·0	+0·868	+0·174	+0·047	−0·006	−0·002	−0·003	1·0	E
69	1·0	+0·877	+0·176	+0·021	−0·033	−0·029	−0·031	1·2	E
70	1·0	+0·885	+0·179	+0·063	+0·008	+0·012	+0·011	1·0	E
71	1·0	+0·962	+0·209	+0·072	+0·011	+0·014	+0·009	1·3	E
72	1·0	+0·982	+0·226	+0·037	−0·025	−0·001		1·0	EM
73	1·0	+0·986	+0·228	+0·060	−0·003	0·000	−0·002	1·1	E
74	1·0	+0·998	+0·270	+0·105	+0·041	+0·003	+0·010	1·1	W
75	1·0	+0·992	+0·278	+0·068	+0·005	+0·007	+0·003	1·2	E
76	1·0	+0·989	+0·281	+0·030	−0·033	−0·011		1·0	M
77	1·0	+0·954	+0·305	+0·046	−0·015	+0·008		1·1	M
78	1·0	+0·950	+0·308	+0·054	−0·007	+0·020		0·8	EM

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Equations of Condition—continued.

No.					Residuals. I.	Residuals. II.	Residuals. III.	Weight.	Position.
				R	R	R	R		
79	$+1{\cdot}0x$	$+0{\cdot}931y$	$+0{\cdot}316z$	$=+0{\cdot}050$	$-0{\cdot}009$	$+0{\cdot}015$		1·1	M
80	1·0	$+0{\cdot}862$	$+0{\cdot}341$	$+0{\cdot}117$	$+0{\cdot}063$	$+0{\cdot}028$	$+0{\cdot}033$	1·0	W
81	1·0	$+0{\cdot}845$	$+0{\cdot}347$	$+0{\cdot}071$	$+0{\cdot}019$	$-0{\cdot}016$	$-0{\cdot}010$	1·0	W
82	1·0	$+0{\cdot}784$	$+0{\cdot}361$	$+0{\cdot}063$	$+0{\cdot}016$	$-0{\cdot}018$	$-0{\cdot}017$	1·0	W
83	1·0	$+0{\cdot}720$	$+0{\cdot}380$	$+0{\cdot}066$	$+0{\cdot}023$	$-0{\cdot}009$	$-0{\cdot}002$	1·0	W
84	1·0	$+0{\cdot}707$	$+0{\cdot}383$	$+0{\cdot}068$	$+0{\cdot}027$	$-0{\cdot}006$	$-0{\cdot}002$	1·0	W
85	1·0	$+0{\cdot}699$	$+0{\cdot}384$	$+0{\cdot}039$	$-0{\cdot}002$	$+0{\cdot}007$	$+0{\cdot}004$	1·0	E
86	1·0	$+0{\cdot}687$	$+0{\cdot}387$	$+0{\cdot}037$	$-0{\cdot}003$	$+0{\cdot}006$	$+0{\cdot}004$	1·0	E
87	1·0	$+0{\cdot}674$	$+0{\cdot}396$	$+0{\cdot}039$	$0{\cdot}000$	$+0{\cdot}010$	$+0{\cdot}006$	1·1	E
88	1·0	$+0{\cdot}670$	$+0{\cdot}391$	$+0{\cdot}055$	$+0{\cdot}017$	$-0{\cdot}015$	$-0{\cdot}008$	1·0	W
89	1·0	$+0{\cdot}648$	$+0{\cdot}395$	$+0{\cdot}065$	$+0{\cdot}028$	$+0{\cdot}038$	$+0{\cdot}032$	1·0	E
90	1·0	$+0{\cdot}634$	$+0{\cdot}398$	$+0{\cdot}029$	$-0{\cdot}007$	$+0{\cdot}003$	$-0{\cdot}003$	1·0	E
91	1·0	$+0{\cdot}630$	$+0{\cdot}399$	$+0{\cdot}042$	$+0{\cdot}007$	$-0{\cdot}024$	$-0{\cdot}022$	1·0	W
92	1·0	$+0{\cdot}578$	$+0{\cdot}410$	$+0{\cdot}059$	$+0{\cdot}028$	$-0{\cdot}002$	$+0{\cdot}004$	1·0	W

The first solution which I have made of these equations is simply taking them as they stand, and giving all the 87 reliable observations equal weights. This leads to the normals—

$$\begin{array}{llll} +87{\cdot}00x & +17{\cdot}59y & -15{\cdot}64z & =-^{R}0{\cdot}145 \\ +17{\cdot}59 & +52{\cdot}15 & +\ 0{\cdot}39 & +3{\cdot}872 \quad [nn]=0{\cdot}3757 \\ -15{\cdot}64 & +\ 0{\cdot}39 & +16{\cdot}19 & +0{\cdot}397 \end{array}$$

and their solution

$$\begin{array}{llll} z=+^{R}0{\cdot}0052, & \text{Probable error} & \pm^{R}0{\cdot}0051 \\ y\ +\ {\cdot}0799 & \text{,,} & \text{,,} & {\cdot}0027 \\ x\ -\ {\cdot}0169 & \text{,,} & \text{,,} & {\cdot}0022 \end{array}$$

$$\pi = 0''{\cdot}650 \pm 0''{\cdot}022$$

Probable error 1 obs. $=\pm 0''{\cdot}236$

I have placed the residuals which the substitution of these values in the equations of condition leaves, under Column I., beside the "Equations of Condition." A glance at them suffices to show the inadmissibility of this solution. At the point where the observations change from one side of the Meridian to the other—between Nos. 53 and 54—these residuals change sign

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without exception ; and in May 1882, where I have been able to secure a number of observations, both East and West of the Meridian, their markedly different character is very apparent. The series is clearly affected by systematic errors dependent in some way on the hour angle of the stars at the time of observation.

From what has been said in the Introduction, I think that all considerations of *instrumental* error being the source of these discrepancies may be immediately dismissed. It is hardly conceivable that there should be any systematic error in the refraction correction, especially as this correction is at its minimum for a large portion of the observations ; and even a large difference in the constant of refraction for α *Centauri* and the comparison stars would affect but little the results of the observations in May 1882, which are decisive as to a systematic difference between the observations on the two sides of the Meridian.

The conclusion appears unavoidable—and it is at the same time the most natural—that the source of these errors is some personality in observing the stars at different hour angles ; and I shall, therefore, attempt to trace these errors to their origin—or, at least, eliminate their effects on this supposition alone.

The circumstances which vary with the hour angle are the zenith-distance, the inclination of the line joining the stars to the horizon, and in the case of α *Centauri*, the apparent position of the companion, which, as seen with the screen used in this series, was a conspicuous star of the 8th magnitude. It is hardly necessary to remark that these two latter varying sources of error might have been eliminated by the use of the reversing prism, had not their influence been under-estimated at the commencement of our work. All these circumstances vary continuously with the hour angle (t), and one of the first modes of treatment which would suggest themselves would be to assume the systematic errors in question to be represented by a mathematical expression of the form

$$\alpha \sin t + \beta \cos t + \gamma \sin 2t + \delta \cos 2t$$

or a similar one with $(p-q)$ as the varying quantity, p being the position angle of the line joining the stars, and q the parallactic angle.

In my case, however, there is good reason to believe these errors do not vary continuously ; but, on the contrary, may be divided into certain definite

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groups, inside of which their variations may be supposed to be but slight. This will be apparent from the following. It was our practice in making the bisections always to turn the head, so that the line joining the stars under observation was either parallel or perpendicular to that joining the eyes. Thus the series would be immediately divided into two groups, according as one or the other of these two positions was employed. It is, therefore, to some extent unfortunate that throughout the greater part of the work the position of the head was not especially noted ; but this omission is not of very serious importance, as for by far the larger and more important portion this position can be inferred with certainty.

It may be considered as certain that, as long as the inclination of the line joining the stars to the horizon was less 40°, the line joining the eyes would be placed parallel to the direction of measurement—especially as I have always preferred this position to the other. This takes place for values of $p-q$ of $90° \pm 40 = 50°$ to $130°$ and $270° \pm 40° = 230°$ to $310°$, and it will be seen from the little Table which follows, where p is taken $= 171°$, that the position in question will have been adopted for all observations *East* of the Meridian up to $12^h{\cdot}0$, and for all observations *West* of the Meridian from $16^h{\cdot}1$ onwards, with the exception of the few at large Western hour angles ; there is every reason, however, to believe that these were made throughout in this same position, which is that in which they were certainly commenced.

Hour Angle.	East.		West.	
	Sidereal Time.	$p-q$.	Sidereal Time.	$p-q$.
h	h	°	h	°
0·0	14·5	171	14·5	171
0·5	14·0	185	15·0	157
1·0	13·5	198	15·5	144
1·5	13·0	210	16·0	132
2·0	12·5	221	16·5	121
3·0	11·5	239	17·5	103
4·0	10·5	254	18·5	88
5·0	9·5	267	19·5	75
6·0	8·5	279	20·5	63
7·0	7·5	291	21·5	51
7·5	7·0	297	22·0	45

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I have placed in the column "Position," beside the "Equations of Condition," the letters E and W to all the observations which were made in the position referred to, *i.e.* with the lines joining the stars and the eyes parallel to one another, according as the stars were East or West of the Meridian. A radical difference between these two classes (E and W) can scarcely be sought for but in the relative position of the companion, which would be seen in the one case (East) to the left, in the other to the right of the principal star; as, on the whole, the direction of measurement with respect to the vertical and the zenith distance would be the same.

These two classes comprise 71 of the 87 observations (40 E, 31 W); the remaining 16 I have classified as follows:

(1) Those which, from the values of $p-q$, were most probably made with the lines joining the eyes and the stars at right angles; these were made near the Meridian, and I have placed the letter M to them in the column "Position" (5 observations).

(2) Those made *East* of the Meridian, which were probably made partly in the one and partly in the other positions of these two lines; these are denoted by EM (5 observations).

(3) Similarly those made *West* of the Meridian, probably in part in the two positions, are called MW (6 observations).

This distribution is to some extent arbitrary, and I have only carried it out in order to be able to give a solution in which all observations are included. It will be obvious that these 16 observations will have little or no weight in determining the parallax—especially as their factors are, as a rule, small; and I consider that by far the best result will be obtained by alone discussing those described as E and W, for which there can be no doubt as to the position of the observer's head.

I now solve the equations under the supposition that the five positions E, EM, M, MW and W, are each affected by a *constant* error. With equal weights for all observations, the normals in x are as follows, those in y and z being easily deduced from them and those of the former solution:

$$\begin{array}{llll} +40{\cdot}00x_{\mathrm{E}} & +22{\cdot}06y & -7{\cdot}93z & =+0{\cdot}844 \\ +\ 5{\cdot}00x_{\mathrm{EM}} & +\ 3{\cdot}36 & -1{\cdot}20 & +\ {\cdot}053 \\ +\ 5{\cdot}00x_{\mathrm{M}} & +\ 3{\cdot}61 & -0{\cdot}21 & +\ {\cdot}088 \\ +\ 6{\cdot}00x_{\mathrm{MW}} & -\ 0{\cdot}15 & -2{\cdot}92 & -\ {\cdot}262 \\ +31{\cdot}00x_{\mathrm{W}} & -11{\cdot}29 & -3{\cdot}38 & -\ {\cdot}868 \end{array}$$

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Their solution gives :

	R	R
z_E	$= -0''.0056$	$\pm 0''.0039$
y	$+ .0971$	$.0024$
x_W	$+ .0068$	$.0030$
x_{MW}	$- .0440$	$.0064$
x_M	$- .0527$	$.0073$
x_{EM}	$- .0560$	$.0072$
x_E	$- .0327$	$.0029$

$$\pi = 0''.790 \pm 0''.020$$

Probable error, 1 obs. $\pm 0''.172$

Leaving out the groups EM, M and MW leads to almost identical results, viz.:

	R	R
z	$= -0''.0076$	$\pm 0''.0040$
y	$+ .0967$	$.0024$
x_W	$+ .0064$	$.0027$
x_E	$- .0337$	$.0027$

$$\pi = 0''.787 \pm 0''.020$$

Probable error, 1 obs. $\pm 0''.167$

The practically identical residuals which these solutions leave are placed in Column II. They show that the objectionable features of the first solution have been diminished to some considerable extent, but not entirely removed. I have, however, considered them as definitive enough to estimate the effect of the atmospheric circumstances on the accuracy of the separate results. It would be interesting, if it were possible, to investigate separately the effects of the sharpness of the definition as given by the "images," and those of the relative motion of the two stars as given by the "steadiness." But it is rare that these two conditions differ by more than one unit of our scale. If the images are diffused, there is sure to be considerable motion, and it only sometimes happens that when the images are good, there are rapid changes of refraction going on, which make them unsteady ; on the contrary, it seldom or never happens that the steadiness is more satisfactory than the images. I have, therefore, contented myself with the following grouping :

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Images.

	1 and 1–2.	2.	2–3 and 3.
No. of observations	21	37	29
Probable error, 1 observation ...	″ 0·146	″ 0·173	″ 0·187
Relative weight	1·41	1·00	0·86

Steadiness.

	1, 1–2 and 2.	2–3.	3 and 3–4.
No. of observations	34	40	13
Probable error, 1 observation ...	″ 0·155	0·173	″ 0·207
Relative weight	1·26	1·00	0·70

There seems to be a marked effect of the atmospheric conditions on the relative accuracy of the measures, and I have given to each observation a weight varying from 1·3 to 0·8, according to the circumstances noted at the time of observation. Any systematic difference for the different qualities of definition appears to be but small, except for the very worst conditions, as we have :—

Images.	Mean Residual. R	Mean Residual. R	Observations
1 and 1–2	−0·0003	±0·0030	21
2	−0·0058	0·0022	37
2–3 and 3	+0·0077	0·0025	29
3–4	+0·0230	0·0059	5

This last value depends, of course, on the five rejected observations, and shows the deviation in the direction of the companion already pointed out. The others follow no marked law, and I have not further considered this point, except to assure myself that no systematic error could be thereby introduced, so casual is the distribution of the different qualities of definition

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Using the above-mentioned weights, the normals become :*

$$
\begin{array}{rrrrl}
41{\cdot}60x_E & +23{\cdot}75y & -8{\cdot}11z & =+\overset{R}{0}{\cdot}969 & \\
4{\cdot}50x_{EM} & +\ 2{\cdot}96 & -1{\cdot}06 & +0{\cdot}037 & \\
4{\cdot}90x_M & +\ 3{\cdot}69 & +0{\cdot}02 & +0{\cdot}098 & \\
5{\cdot}70x_{MW} & -\ 0{\cdot}17 & -2{\cdot}76 & -0{\cdot}247 & [p.nn] = 0{\cdot}3809 \\
31{\cdot}60x_W & -11{\cdot}60 & -3{\cdot}51 & -0{\cdot}905 & \\
\left.\begin{array}{l}+23{\cdot}75x_E + 2{\cdot}96x_{EM} + 3{\cdot}69x_M \\ \quad -0{\cdot}17x_{MW} - 11{\cdot}60x_W\end{array}\right\} & +53{\cdot}51 & +0{\cdot}47 & +3{\cdot}970 & \\
\left.\begin{array}{l}-\ 8{\cdot}11x_E - 1{\cdot}06x_{EM} + 0{\cdot}02x_M \\ \quad -2{\cdot}76x_{MW} - 3{\cdot}51x_W\end{array}\right\} & +\ 0{\cdot}47 & +16{\cdot}35 & +0{\cdot}384 &
\end{array}
$$

solving them gives

$$
\begin{array}{lrr}
z & =-\overset{R}{0}{\cdot}0052 & \pm\ \overset{R}{0}{\cdot}0038 \\
y & +\ {\cdot}0969 & {\cdot}0025 \\
x_W & +\ {\cdot}0063 & {\cdot}0025 \\
x_{MW} & -\ {\cdot}0430 & {\cdot}0059 \\
x_M & -\ {\cdot}0529 & {\cdot}0063 \\
x_{EM} & -\ {\cdot}0569 & {\cdot}0066 \\
x_E & -\ {\cdot}0331 & {\cdot}0027
\end{array}
$$

$$\pi = 0''{\cdot}789 \pm 0''{\cdot}020$$

Probable error, 1 obs., of weight 1 $\pm\ 0''{\cdot}172$.

The solution with E and W alone is

$$
\begin{array}{lrr}
z & =-\overset{R}{0}{\cdot}0072 & \pm\ \overset{R}{0}{\cdot}0041 \\
y & +\ {\cdot}0964 & {\cdot}0024 \\
x_W & +\ {\cdot}0061 & {\cdot}0027 \\
x_E & -\ {\cdot}0334 & {\cdot}0026
\end{array}
$$

$$\pi = 0''{\cdot}785 \pm 0''{\cdot}020$$

Probable error, 1 obs., of weight 1 $\pm\ 0''{\cdot}167$.

These results are identical with those of the unweighted observations, and lead, of course, to the same residuals, those in Column II. As before

* I may remark here that it would have been perhaps advisable to have given also diminished weights to the four incomplete observations; they agree, however, well with the surrounding results, so that little or no change would be thereby introduced into the final deductions.

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remarked, these still show some traces of systematic error, and it appears not unlikely that this is due to the assumption of a constant error affecting each group. Although throughout each group the position of the companion —to whose disturbing effect probably the larger portion of these discrepancies are to be attributed—with respect to the eye was the same, still the turning of the head through ±40°, and the variations of zenith distance, may have had some considerable influence on the results. To test this I have arranged the residuals of the two groups E and W in order of hour angle, and the result will be found in the little Table which follows. The groups EM, M, and MW are not numerous enough to admit of this, and I do not propose to further consider them. The above solutions, with and without them, show that they are of no appreciable influence in determining the parallax, and on account of the uncertainty respecting the position of the head they are of little or no use in estimating the systematic errors of the series. The Table referred to is as follows:

East.			West.		
Sidereal Time.	Mean Residual.	Observations.	Sidereal Time.	Mean Residual.	Observations.
h	R		h	R	
7·9	−0·0063	9	17·9	−0·0064	9
8 9	− ·0021	8	19·3	− ·0032	12
10·6	+ ·0051	11	20·9	+ ·0085	10
11·5	+ ·0028	12			

Although the probable error of each one of these values is about ±0^{R}·0040, still they show, both East and West, a well marked progressive change which will have to be taken into account. Instead of assuming x_E and x_W therefore to be constant, I shall consider them as varying with the time, and the square of the time counted from a middle epoch of the group. In adopting this simple law I have been influenced by the consideration that, whatever may be the source of this variation, it most probably will be approximately represented over the four hours or so of each group by an algebraical expression of this form; and considering the smallness of these variations, the course is, I think, quite justified.

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I therefore introduce the new unknowns :—

e_1, coefficient (Sidereal time $-$ ^{h}10·0)
e_2, „ („ „ $-10{\cdot}0)^2$
w_1, „ („ „ $-19{\cdot}5)$
w_2, „ („ „ $-19{\cdot}5)^2$

with which the normals for the two classes E and W become :

East.

					^{R}	
$+41{\cdot}60x_E$	$+23{\cdot}75y$	$-8{\cdot}11z$	$-1{\cdot}61e_1$	$+85{\cdot}10e_2$	$=+0{\cdot}969$	
$+23{\cdot}75$	$+26{\cdot}28$	$-7{\cdot}63$	$+23{\cdot}64$	$+22{\cdot}90$	$+1{\cdot}892$	
$-8{\cdot}11$	$-7{\cdot}63$	$+9{\cdot}77$	$-3{\cdot}62$	$-4{\cdot}67$	$-0{\cdot}532$	$[p.nn]=0\,1766$
$-1{\cdot}61$	$+23{\cdot}64$	$-3{\cdot}62$	$+85{\cdot}10$	$-54{\cdot}52$	$+2{\cdot}568$	
$+85{\cdot}10$	$+22{\cdot}90$	$-4{\cdot}67$	$-54{\cdot}52$	$+298{\cdot}23$	$-0{\cdot}862$	

West.

					^{R}	
$+31{\cdot}60x_W$	$-11{\cdot}60y$	$-3{\cdot}51z$	$-3{\cdot}23w_1$	$+52{\cdot}88w_2$	$=-0{\cdot}905$	
$-11{\cdot}60$	$+21{\cdot}39$	$+7{\cdot}78$	$-16{\cdot}34$	$-16{\cdot}48$	$+1{\cdot}848$	
$-3{\cdot}51$	$+7{\cdot}78$	$+3{\cdot}40$	$-3{\cdot}68$	$-2{\cdot}36$	$+0{\cdot}697$	$[p.nn]=0{\cdot}1702$
$-3{\cdot}23$	$-16{\cdot}34$	$-3{\cdot}68$	$+52{\cdot}88$	$+5{\cdot}78$	$-1{\cdot}275$	
$+52{\cdot}88$	$-16{\cdot}48$	$-2{\cdot}36$	$+5{\cdot}78$	$+202{\cdot}41$	$-0{\cdot}955$	

Adding the two sets of normals, and solving, I find

	^{R}	^{R}
$z=$	$-0{\cdot}0033$	$\pm 0{\cdot}0043$
y	$+0{\cdot}0961$	$\pm 0{\cdot}0034$

	^{R}	^{R}		^{R}	^{R}
$e_2=$	$-0{\cdot}0021$	$\pm 0{\cdot}0015$	$w_2=$	$+0{\cdot}0020$	$\pm 0{\cdot}0012$
e_1	$+{\cdot}0015$	${\cdot}0017$	w_1	$+{\cdot}0053$	${\cdot}0021$
x_E	$-{\cdot}0280$	${\cdot}0050$	x_W	$+{\cdot}0034$	${\cdot}0034$

$$\pi = 0''{\cdot}783 \pm 0''{\cdot}028$$

Probable error, 1 obs., of weight 1 $\pm 0''{\cdot}161$

The residuals for this solution are found in Column III., and, on the whole, I think the observations are now fairly well represented. The effect of the new unknowns on the parallax itself has been quite insensible.

A final test will be to deduce the parallax from the two series E and W separately.

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The E observations give, solved alone—

East.

	R	R
z	$=-0^{R}\cdot0025$	$\pm\ 0^{R}\cdot0049$
y	$+\ \cdot1000$	$\cdot0062$
e_2	$-\ \cdot0017$	$\cdot0016$
e_1	$+\ \cdot0006$	$\cdot0021$
x_E	$-\ \cdot0307$	$\cdot0062$

$$\pi = 0''\cdot815 \pm 0''\cdot051$$

Probable error, 1 obs. $\pm\ 0''\cdot166$

From the W series both y and z cannot be simultaneously determined; z would come out with a weight of only 0·33, as the observations do not embrace a whole year. I therefore use for these observations the value of z derived from the E series ($-0^{R}\cdot0025$) and I find then

West.

	R	R
y	$=+0^{R}\cdot0938$	$\pm\ 0^{R}\cdot0044$
w_2	$+\ \cdot0028$	$\cdot0012$
w_1	$+\ \cdot0045$	$\cdot0022$
x_W	$+\ \cdot0025$	$\cdot0035$

$$\pi = 0''\cdot764 \pm 0''\cdot036$$

Probable error, 1 obs. $\pm\ 0''\cdot157$

The two values for the parallax agree within their probable errors.

With this I close the discussion of the series, and I have only a few general remarks more to make. In the first place I may state that, it being our custom to reduce the observations approximately shortly after their being made, the break between Nos. 53 and 54, when the observations change from one side of the Meridian to the other, soon became apparent, and led to the simultaneous observations East and West, in May 1882, which put the systematic difference of the two positions beyond all doubt. It thus became necessary to take this systematic difference into account, and an advantage of the pair which was not expected to be of such value when the stars were selected, viz. that the change from one side of the Meridian to the other

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occurs when the parallax factor is still considerable, has resulted in a lesser loss of weight than would have otherwise been the case.

The first solution which ignores this systematic difference I have given only to show at a glance (from the residuals in Column I.) the nature of the errors, and the parallax derived in that solution has no value whatever. The second group of solutions, for which the residuals are given in Column II., assumes the constancy of the discrepancies over a considerable range of hour angle, &c., and cannot be considered in this respect as exhaustive. The final solution, in which the errors are supposed to be represented by an algebraical function of the hour angle, meets, I think, all reasonable demands. At least I can imagine no source of error which would not be approximately represented by an expression of this kind. The two solutions from the E and W series, which are quite independent, except that the same proper motion correction has been taken for both, show that no violence has been done in combining both into one.

As to the final value of the relative parallax deducible from the series, from the moment the necessity is seen of allowing for the systematic errors of the observations, the series points most pronouncedly to a value

$$0''\!\cdot\!78 \pm 0''\!\cdot\!028$$

which must be accepted as its definitive result.

And I do not think that the uncertainty of the determination is appreciably greater than its probable error would imply. The only source of error not already taken into account, which has occurred to me, is a possible variation in the systematic errors caused, for instance, by the change in the relative position of the companion. If such a variation has taken place gradually, it must affect but slightly the results from the E series, more considerably those from the W series. But there is no evidence whatever of the existence of such a change. The proper motion correction comes out not dissimilar to that which might be expected from the Meridian observations of the comparison stars, and there is no serious discrepancy between the E and W series. Furthermore, considering the continuity of the observations, I do not think any sudden large changes are probable, and such are certainly not shown by the observations themselves.

The diagram (Plate III.) shows at a glance the deviations of the obser-

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vations from the theoretical curve, both before and after application of the systematic corrections. The different groups are distinguished as follows :—

E ... ...
W ... ...
EM ... ...
M ... ...
MW ... ...

In this latter case, for the last three groups the values of x have been taken

$$\overset{R}{-0{\cdot}056},\ \overset{R}{-0{\cdot}052},\ \text{and}\ \overset{R}{-0{\cdot}043}\ \text{respectively},$$

y and z the same as for the two other groups.

§ 4. *Parallax of α Centauri. 2nd Series.* Elkin.

The observations of α_2 *Centauri* and the fainter pair of comparison stars a' and b' were intended to be restricted to such made near the epochs of the two maxima of parallax, and the series will therefore be found to consist of three groups made in or about August 1881, February 1882, and August 1882, and furthermore of a group made in April 1883. The three first groups are all near the parallax maxima, and the middle one has about double the number of observations of each of the other two, so as to equalise the weight of each maximum. The final group in April 1883 consists, I may immediately state, of observations made East and West of the Meridian, and was found to be necessary to insure the freedom of the series from systematic error, such as we had found to exist in the other series on *α Centauri*.

The pair itself left little to be desired as regards symmetry, the two comparison stars being very equal in magnitude, and very symmetrically situated with reference to *α Centauri*—the approximate positions being

	Distance.	Position Angle.
α_2 Centauri-a', 8 Magnitude	$\overset{R}{228{\cdot}4} = 49'{\cdot}0$	$274^\circ\ 44'$
α_2 Centauri-b', 8 „	$217{\cdot}6 = 46{\cdot}7$	$91^\circ\ 30'$
Difference	10·8	183 14

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The screen which was used to reduce the light of the bright star was so constructed as to practically obliterate the fainter companion, α_1 *Centauri*; and, in fact, this latter could only be seen through it on careful scrutiny, α_2 *Centauri*, the principal star, appearing about of the $8\frac{1}{4}$ magnitude, or a trifle fainter than the comparison stars.

The annual proper motion of α_2 *Centauri* along the lines joining the stars is formed from the same elements as before, to be

	α_2 Centauri-a'.	α_2 Centauri-b'.
	R	R
1881·0	−0·2541	+0·2479
1882·0	·2546	·2486
1883·0	·2553	·2494

and the reduction for aberration amounts to

R
α_2 Centauri-a' ... ... +0·0166 sin ($\odot$ + 122°·4)
α_2 Centauri-b' ... ... +0·0160 sin ($\odot$ + 121·5)

The observations which now follow are corrected for aberration, and reduced to 1882·0 with the above values for the proper motion of α_2 *Centauri*, that of the comparison stars being assumed =0, as there are no observations of these stars earlier than 1875.

Observations.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	α_2 Cent.-a'.	α_2 Cent.-b'.
	1881.	h m			°	R	R
1	July 16	18 29	2–3	2–3	56·3	228·374	217·672
2	18	16 7	2	2	42·4	·381	·661
3	Aug. 8	17 13	2	2	51·5	·341	·638
4	10	20 52	2–3	3	47·4	·343	·635
5	11	18 13	1–2	2	45·6	·351	·659
6	13	17 40	1–2	2	52·2	·345	·628
7	14	19 32	3	3	54·3	·343	·671
8	16	20 2	2	2	55·8	·353	·639
9	18	19 6	3	3	55·0	·352	·640

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Observations—continued.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	α_2 Cent.-a'.	α_2 Cent.-b'.
	1882.	h m			°	R	R
10	Jan. 20	11 0	2–3	2–3	61·5	228·432	217·537
11	22	8 34	3	3	69·5	·413	·536
12	28	10 44	2	2	60·0	·441	·568
13	Feb. 3	11 2	2	2	55·5	·429	·564
14	5	9 21	2	2–3	59·0	·442	·542
15	6	8 56	3	3	62·5	·451	·543
16	8	12 40	2	2	64·0	·468	·589
17	10	11 43	2	2–3	62·5	·452	·575
18	11	11 2	2–3	2–3	70·0	·428	·555
19	12	10 47	3	3	66·0	·410	·558
20	13	12 38	2	2	67·0	·444	·571
21	16	12 16	1	1	59·0	·469	·571
22	17	8 43	3	3	64·0	·428	·557
23	18	9 53	3	3	65·0	·435	·527
24	25	10 29	2	2	61·5	·399	·562
25	Mar. 4	10 8	2	2	60·0	·448	·568
26	Aug. 1	18 36	2	2–3	56·0	·378	·620
27	2	20 17	2	2	58 0	·351	·620
28	3	19 43	2–3	3	56·0	·381	·624
29	6	20 13	2–3	2	44·5	·344	·631
30	7	19 37	2	2–3	55·0	·375	·621
31	11	19 28	2	2	51·0	·354	·613
32	12	19 42	1	1	50·2	·359	·634
33	18	20 6	2	2	47·0	·358	·674
	1883.						
34	April 3	10 14	3	3	52·0	·384	·606
35	3	17 29	1–2	1–2	56·0	·469	·560
36	4	17 31	1–2	1–2	50·0	·461	·562
37	5	11 41	1–2	1–2	56·0	·445	·585
38	7	17 47	2	2	52·0	·442	·569
39	8	11 32	1–2	1–2	62·0	·443	·566
40	9	11 49	1–2	1–2	50·0	·410	·577
41	10	18 6	2	2	54·0	·465	·554

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Observations—continued.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	α_2 Cent.-a'.	α_2 Cent.-b'.
	1883.	h m			°	R	R
42	April 12	18 10	2	2–3	57·0	228·438	217·568
43	14	17 36	3	3	59·0	·431	·572
44	16	10 25	2	2–3	60·0	·440	·613
45	18	17 45	2–3	2–3	60·0	·512	·585
46	20	10 12	2	2	60·5	·450	·632
47	23	11 42	1–2	2	57·5	·441	·597
48	23	18 2	2	2	56·5	·462	·580
49	25	10 31	1–2	2–3	59·5	·422	·563
50	28	10 34	2	2	57·5	·445	·603

The equations of condition formed from the *differences* of the two distances α_2 *Centauri-a'*—α_2 *Centauri-b'* are contained in the next Table, x being the correction to the assumed mean difference

$$\overset{R}{10{\cdot}800}$$

for 1882·0, y is $= 1{\cdot}920\ \pi$, the parallax factor being given by

$$+1{\cdot}920 \sin (\odot + 137\overset{\circ}{\cdot}4) \cdot R,$$

and z the correction to the assumed proper motion. The columns of *Residuals* and *Weights* I place as usual beside the Equations of Condition. In forming the absolute term the actually observed distance has been corrected by the formula

$$-(\text{Observed } sum - \overset{R}{446{\cdot}000})\frac{10{\cdot}8}{446{\cdot}0},$$

which correction never exceeds $0^R{\cdot}002$ for this pair. The mean of the fifty observed sums (reduced to 1882·0) is

$$\overset{R}{446{\cdot}007},$$

and the effect of a parallax of α *Centauri* on the sums is given by

$$+0{\cdot}041 \sin (\odot + 333\overset{\circ}{\cdot}2) \cdot R,$$

which need not be taken into account.

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Of these observations there is one which I do not propose to include in determining the parallax, No. 24. The note-book contains the remark, "Only cleared up and dome opened just before observing." And furthermore the order of observing usually followed was not strictly carried out on this occasion, presumably to save time on account of the unsettled weather.

Equations of Condition.

No.					Residuals.			Weight.	Position.
					I.	II.	III.		
				R	R	R	R		
1	$+1{\cdot}0x$	$-0{\cdot}964y$	$-0{\cdot}459z$	$=-0{\cdot}099$	$-0{\cdot}005$	$-0{\cdot}008$	$-0{\cdot}007$	0·7	W
2	1·0	0·973	0·454	$-0{\cdot}081$	$+0{\cdot}014$	$+0{\cdot}011$	$+0{\cdot}011$	1·0	W
3	1·0	1·013	0·396	$-0{\cdot}097$	$-0{\cdot}000$	$-0{\cdot}002$	$-0{\cdot}002$	1·0	W
4	1·0	1·009	0·390	$-0{\cdot}092$	$+0{\cdot}004$	$+0{\cdot}002$	$+0{\cdot}002$	0·7	W
5	1·0	1·007	0·388	$-0{\cdot}108$	$-0{\cdot}012$	$-0{\cdot}014$	$-0{\cdot}014$	1·2	W
6	1·0	1·003	0·385	$-0{\cdot}083$	$+0{\cdot}012$	$+0{\cdot}011$	$+0{\cdot}010$	1·2	W
7	1·0	1·000	0·380	$-0{\cdot}128$	$-0{\cdot}033$	$-0{\cdot}035$	$-0{\cdot}034$	0·4	W
8	1·0	0·993	0·374	$-0{\cdot}086$	$+0{\cdot}008$	$+0{\cdot}006$	$+0{\cdot}006$	1·0	W
9	1·0	$-0{\cdot}985$	$-0{\cdot}369$	$-0{\cdot}087$	$+0{\cdot}006$	$+0{\cdot}004$	$+0{\cdot}004$	0·4	W
10	1·0	$+0{\cdot}913$	$+0{\cdot}056$	$+0{\cdot}096$	$+0{\cdot}021$	$+0{\cdot}023$	$+0{\cdot}023$	0·7	E
11	1·0	0·930	0·061	$+0{\cdot}078$	$+0{\cdot}001$	$+0{\cdot}003$	$+0{\cdot}003$	0·4	E
12	1·0	0·957	0·078	$+0{\cdot}073$	$-0{\cdot}007$	$-0{\cdot}005$	$-0{\cdot}005$	1·0	E
13	1·0	0·978	0·094	$+0{\cdot}065$	$-0{\cdot}017$	$-0{\cdot}015$	$-0{\cdot}015$	1·0	E
14	1·0	0·982	0·100	$+0{\cdot}100$	$+0{\cdot}017$	$+0{\cdot}019$	$+0{\cdot}018$	1·0	E
15	1·0	0·983	0·102	$+0{\cdot}108$	$+0{\cdot}025$	$+0{\cdot}027$	$+0{\cdot}026$	0·4	E
16	1·0	0·986	0·108	$+0{\cdot}078$	$-0{\cdot}005$	$-0{\cdot}004$	$-0{\cdot}004$	1·0	E
17	1·0	0·987	0·113	$+0{\cdot}076$	$-0{\cdot}007$	$-0{\cdot}006$	$-0{\cdot}006$	1·0	E
18	1·0	0·987	0·116	$+0{\cdot}073$	$-0{\cdot}010$	$-0{\cdot}009$	$-0{\cdot}009$	0·7	E
19	1·0	0·987	0·119	$+0{\cdot}053$	$-0{\cdot}030$	$-0{\cdot}029$	$-0{\cdot}029$	0·4	E
20	1·0	0·986	0·122	$+0{\cdot}073$	$-0{\cdot}010$	$-0{\cdot}009$	$-0{\cdot}009$	1·0	E
21	1·0	0·983	0·130	$+0{\cdot}097$	$+0{\cdot}014$	$+0{\cdot}015$	$+0{\cdot}014$	1·2	E
22	1·0	0·982	0·133	$+0{\cdot}072$	$-0{\cdot}011$	$-0{\cdot}010$	$-0{\cdot}010$	0·4	E
23	1·0	0·980	0·135	$+0{\cdot}109$	$+0{\cdot}026$	$+0{\cdot}027$	$+0{\cdot}026$	0·4	E
24	1·0	0·975	0·155	$+0{\cdot}038$	[$-0{\cdot}045$]	[$-0{\cdot}044$]	[$-0{\cdot}044$]		E
25	1·0	$+0{\cdot}969$	0·174	$+0{\cdot}080$	$-0{\cdot}003$	$-0{\cdot}002$	$-0{\cdot}003$	1·0	E
26	1·0	$-1{\cdot}013$	0·584	$-0{\cdot}042$	$+0{\cdot}028$	$+0{\cdot}027$	$+0{\cdot}025$	1·0	W
27	1·0	1·013	0·587	$-0{\cdot}068$	$+0{\cdot}000$	$+0{\cdot}001$	$-0{\cdot}001$	1·0	W
28	1·0	1·014	0·590	$-0{\cdot}043$	$+0{\cdot}025$	$+0{\cdot}026$	$+0{\cdot}023$	0·7	W
29	1·0	1·014	0·598	$-0{\cdot}086$	$-0{\cdot}018$	$-0{\cdot}017$	$-0{\cdot}019$	0·7	W
30	1·0	1·013	0·601	$-0{\cdot}046$	$+0{\cdot}022$	$+0{\cdot}023$	$+0{\cdot}020$	1·0	W

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Equations of Condition—continued.

No.					Residuals.			Weight.	Position.
					I.	II.	III.		
31	$+1{\cdot}0x$	$-1{\cdot}007y$	$+0\,612z=$	R $-0{\cdot}058$	R $+0{\cdot}009$	R $+0{\cdot}010$	R $+0{\cdot}008$	1·0	W
32	1·0	1·005	0·614	−0·075	−0·008	−0·007	−0·009	1·2	W
33	1·0	−0·986	0·631	−0·117	−0·052	−0·052	−0·054	1·0	W
34	1·0	+0·482	1·256	−0·022		−0·081	−0·085	0·4	E
35	1·0	0·479	1·257	+0·109		+0·007	+0·007	1·2	W
36	1·0	0·463	1·259	+0·099		−0·002	−0·002	1·2	W
37	1·0	0·451	1·261	+0·059		+0·003	−0·001	1·2	E
38	1·0	0·418	1·267	+0·073		−0·023	−0·023	1·0	W
39	1·0	0·406	1·270	+0·077		+0·025	+0·020	1·2	E
40	1·0	0·390	1·273	+0·034		−0·016	−0·020	1·2	E
41	1·0	0·373	1·276	+0·110		+0·018	+0·018	1·0	W
42	1·0	0·340	1·281	+0·070		−0·019	−0·018	1·0	W
43	1·0	0·307	1·287	+0·059		−0·026	−0·026	0·4	W
44	1·0	0·279	1·291	+0·026		−0·013	−0·018	1·0	E
45	1·0	0·243	1·297	+0·125		+0·046	+0·045	0·7	W
46	1·0	0·212	1·302	+0·016		−0·017	−0·021	1·0	E
47	1·0	0·162	1·310	+0·043		+0·015	+0·010	1·2	E
48	1·0	0·142	1·311	+0·081		+0·012	+0·011	1·0	W
49	1·0	0·130	1·316	+0·060		+0·035	+0·030	1·2	E
50	1·0	0·079	1·325	+0·041		+0·021	+0·016	1·0	E

The solution which was first made of these equations was one including only the first three groups, having been made in fact before the last group in April 1883 had been observed. With equal weights for all equations, excepting No. 24, as already explained, the normals are found :

$$\begin{aligned} &+32{\cdot}00x - 2{\cdot}42y + 2{\cdot}86z = \overset{R}{-0{\cdot}165} \\ &-\ 2{\cdot}42 \quad +31{\cdot}22 \quad +0{\cdot}32 \quad +2{\cdot}591\ [nn] = 0{\cdot}2292 \\ &+\ 2{\cdot}86 \quad +\ 0{\cdot}32 \quad +4{\cdot}54 \quad +0{\cdot}153 \end{aligned}$$

which gives for the unknown quantities and their probable errors—

$$\begin{aligned} x &= \overset{R}{-0{\cdot}0015} \pm \overset{R}{0{\cdot}0024} \\ y &+ {\cdot}0826 \quad {\cdot}0023 \\ z &+ {\cdot}0289 \quad {\cdot}0063 \end{aligned}$$

$$\pi = 0''{\cdot}553 \pm 0''{\cdot}016$$

Probable error of 1 obs. $\pm 0''{\cdot}167$.

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The residuals which remain after the substitution of these values in the equations of condition are found in Column I. Each group is in the mean, of course, represented, and the accuracy of the observations is satisfactory, only one residual (No. 33) amounting to more than $0''.5$.

But the values of the unknown quantities which result from this solution, bearing in mind the deductions from the other pairs for *α Centauri*, must appear very unsatisfactory. The large correction to the assumed proper motion would imply either a change in the mode of observing, or considerable motions of one or both of the comparison stars. In the first of these cases the parallax determination might be largely vitiated, and in the second case the weight of this determination, considered as one of an absolute parallax, would have to be considerably diminished.

Furthermore, the numerical value for the parallax of *α Centauri* disagrees entirely with the results from the other pairs. This might be due to either one of the causes just mentioned, or it might arise from a systematic error such as had been found in our other pairs, although we had hoped to avoid such by the precaution of diminishing the light of the companion. This latter point I determined to investigate, and hence the series of simultaneous observations East and West of the Meridian in April 1883. I may state here that every precaution was taken during these observations to insure freedom from bias; the reductions were not undertaken until the greater part of the observations were completed, and I feel confident that an unprejudiced result has been attained. This result from this series of observations in April 1883 goes to show that a large systematic difference really existed between the observations on the two sides of the Meridian, the seventeen observations giving—

$$\text{West}-\text{East} = \overset{R}{+0''.051}\ (\overset{R}{\pm 0''.010}) - 0''.073y + 0''.010z.$$

The first solution must therefore be considered as worthless as far as the deduction of the relative parallax is concerned, and I pass to the discussion of the complete series.

Assuming x to be different East and West of the Meridian, the forty-nine reliable equations furnish the normals :—

$$\begin{array}{lllll} +24''.00x_E & 0''.00x_W & +17''.18y & +13''.24z = \overset{R}{+1''.565} & \\ 0''.00 & +25''.00 & -14''.24 & +11''.46 & +1''.551\ [nn] = 0''.3180 \\ +17''.18 & -14''.24 & +33''.19 & +7''.15 & +2''.931 \\ +13''.24 & +11''.46 & +7''.15 & +32''.60 & +1''.512 \end{array}$$

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Their solution gives—

$$x_E = -0''.0231 \pm 0''.0048$$
$$x_W \quad + \cdot 0201 \quad \cdot 0048$$
$$y \quad + \cdot 1033 \quad \cdot 0047$$
$$z \quad + \cdot 0261 \quad \cdot 0037$$

$$\pi = 0''.672 \pm 0''.031$$

Probable error of 1 obs. $\pm$ 0·207.

The residuals for this solution are found in Column II. beside the equations of condition. I have used them to estimate the influence of the atmospheric conditions on the observations. I find—

Images.	1 and 1–2.	2.	2–3.	3.
Probable error of 1 obsrvtn.	0″·151	0″·165	0″·211	0″·316
No. of observations ...	11	22	7	9
Relative weight	1·19	1·00	0·60	0·27
Adopted weight	1·2	1·0	0·7	0·4

Steadiness.	1 and 1–2.	2.	2–3.	3.
Probable error of 1 obsrvtn.	0″·121	0″·156	0″·216	0″·295
No. of observations ...	7	20	11	11
Relative weight	1·65	1·00	0·52	0·30

From which it appears the quality of the definition has had a large effect on the observations. I have considered the "images" as preponderating in this case, and assigned the approximate weights stated above. Systematic differences for the different qualities appear to be very small, the mean residuals being—

Images.	Mean Residual.	Observations.
1 and 1–2	$+0''.0065$	11
2	$-$ ·0008	22
2–3	+ ·0092	7
3	$-$ ·0133	9

and follow no pronounced law.

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The normals which are found by using these weights now follow, those from the *East* and *West* observations being kept distinct.

East.

			R
$+21{\cdot}00x$	$+13{\cdot}90y$	$+13{\cdot}42z$	$=+1{\cdot}349$
$+13{\cdot}90$	$+11{\cdot}91$	$+4{\cdot}60$	$+1{\cdot}035$ $[p.nn]=0{\cdot}1017$
$+13{\cdot}42$	$+4{\cdot}60$	$+15{\cdot}83$	$+0{\cdot}623$

West.

			R
$+22{\cdot}70x$	$-12{\cdot}53y$	$+11{\cdot}11z$	$=-0{\cdot}529$
$-12{\cdot}53$	$+16{\cdot}31$	$+1{\cdot}84$	$+1{\cdot}474$ $[p.nn]=0{\cdot}1741$
$+11{\cdot}11$	$+1{\cdot}84$	$+16{\cdot}22$	$+0{\cdot}860$

The solution of the *sum* of these two sets of normals—that is, of the complete series—is as follows :—

	R	R
x_E	$=-0{\cdot}0206$	$\pm 0{\cdot}0042$
x_W	$+{\cdot}0185$	${\cdot}0042$
y	$+{\cdot}1009$	${\cdot}0041$
z	$+{\cdot}0282$	${\cdot}0033$

$$\pi = 0''{\cdot}676 \pm 0''{\cdot}027$$

Probable error, 1 obs. of Weight 1 $0{\cdot}176$.

It is not practicable to solve the two sets of normals separately, as the East set is formed from only two groups of observations, from which it is evidently impossible to determine three unknowns. If, however, we take z as it is derived from the whole series, the two independent values of y are found

		R	R
From the East observations	$y=$	$+0{\cdot}0976$	$\pm 0{\cdot}0105$
„ West „	$y=$	$+0{\cdot}1018$	$0{\cdot}0056$

which are in close agreement.

The residuals for this solution are found in Column III., and neither they nor the values of the unknowns are sensibly different from those given by the unweighted observations. The new group in April 1883 confirms the correction to the assumed proper motion given by the first solution. With regard to this correction, the *sums* of the observed distances now seem to offer some slight

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evidence that it may be due to a motion of one of the comparison stars, the mean of each group being as follows:—

Date.	Sum.	Temperature.	Position.	Observation.
	R	°		
1881·60	446·003	51·2	W	9
1882·11	445·995	62·9	E	16
1882·60	445·992	52·2	W	8
1883·29	446·025	57·4	E	9
1883·29	446·029	55·6	W	8

This would seem to lead the suspicions of motion on to star a'.

The systematic difference between the East and West observations has of course influenced largely the parallax result. Before, however, accepting this as final, I have arranged the residuals in order of hour angles, which leads to the following little Table, derived from Column III. and the adopted weights:—

East.			West.		
Sidereal Time.	Mean Residual.	Observations.	Sidereal Time.	Mean Residual.	Observations.
h	R		h	R	
9·7	−0·0036	8	17·4	+0·0007	8
10·7	+ ·0036	8	18·7	+ ·0014	9
12·0	+ ·0007	8	20·0	− ·0042	8

There appears to be no very large progressive change depending upon the hour angle on one and the same side of the Meridian, the result for $20^h{\cdot}0$ arising only from one large residual, without which a small positive value would be obtained. I have, therefore, not thought it worth while to consider this point further as the distribution of the observations is to a very large extent casual.

The value

$$0''{\cdot}676 \pm 0''{\cdot}027$$

might therefore be taken with considerable confidence as the parallax of

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α_2 *Centauri* relative to a' and b', but for the circumstance that the observations which determine the systematic difference East and West of the Meridian were made much later (a full year) than the bulk of the series. Should the subjective error be due to the disturbing effect of the companion, in spite of our precautions, this will have moved considerably during this period, though in the direction, it must be said, which would be the least likely to affect the measures. If, on the other hand, the source of the discrepancies be sought in the very slightly lesser brilliancy of the reduced α_2 *Centauri*, there is no special reason to suspect any changes in my mode of observing, for although this particular pair was dropped for months at a time, still my Heliometer observations continued almost uninterruptedly over my whole stay at the Cape.

Since finishing this paper in its above form, I have received Dr. Gill's result from his second pair of comparison stars for α *Centauri*, in which he finds considerable evidence of a term depending upon the square of the time in the motion of α_2 *Centauri*. As his pair and the one under discussion here lie nearly along the same position angle, it therefore becomes of some interest to test this series in this respect. The additional normal (in z') is, using the adopted weights—

$$+15\cdot79x_E + 16\cdot24x_W + 4\cdot77y + 37\cdot03z + 47\cdot28z' = +1\cdot508^R$$

and the solution becomes—

		R
z'	$= +0\cdot0014$	$\pm 0\cdot0072$
z	$+ \cdot0268$	$\cdot0083$
y	$+ \cdot1009$	$\cdot0041$
x_W	$+ \cdot0183$	$\cdot0044$
x_E	$- \cdot0207$	$\cdot0044$

$$\pi = 0''\cdot676 \pm 0''\cdot027$$

Probable error, 1 obs. $\pm 0''\cdot178$

This series does, therefore, not confirm Dr. Gill's result, z' coming out much smaller than its probable error. The whole amount of the assumed variation of the annual motion is so small in this case (less than $0''\cdot1$), that

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the uncertainty of the adopted ratio of masses of α_1 and α_2 *Centauri* can have no appreciable effect; if the existence of such a term were proved, it would have to be laid to the charge of the assumed variation of the relative position of α_1 and α_2 *Centauri*. This has been deduced from the orbit above mentioned, which represents the whole series of micrometrical observations, including our own, during the period covered by the above series, and does not appear likely to be very much in error, though, of course, this is a question which only accumulated observation can answer.

§ 5. *Parallax of Sirius.* GILL.

The observations which I have made to determine the parallax of *Sirius* consist of measures of its angular distance from the comparison stars α and β mentioned in the Introduction.

The series consists of measures on 79 days, extending from August 29, 1881, to May 12, 1883, of which 13 are half sets, the remainder are complete observations. During the months of June and July *Sirius* is too near the Sun to permit of observations being made at suitable altitudes; but, with the exception of these months, the observations are pretty uniformly distributed over the first year.

During September and October 1882, the observations of *Victoria* and *Sappho* which I had undertaken, prevented the further regular continuance of the series, and the observations thereafter were confined to the epochs of maximum and minimum parallax, excepting on four nights about the end of February 1883—a nearly intermediate epoch. The position of *Sirius*, referred to the stars of comparison, is as follows:—

Relative to	Magnitude.	Distance.	Position Angle.
		R	°
Star α	7	286·4	310·21
„ β	7	282·0	144·90

Hence the parallax factors for measures of distance are

From star α ... ... $0{\cdot}897 . R . \cos(\odot - 216{\cdot}56^\circ)$

„ β ... ... $0{\cdot}809 . R . \cos(\odot - 49{\cdot}43)$

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the difference and sum of which are

$$\text{For distance } \alpha - \beta \quad \ldots \quad 1{\cdot}695 \,.\, R \,.\, \cos\,(\odot - 222^{\circ}{\cdot}66)$$
$$\text{,,} \quad \alpha + \beta \quad \ldots \quad 0{\cdot}210 \,.\, R \,.\, \cos\,(\odot - 157{\cdot}6\,)$$

The two stars of comparison are of very equal magnitude; and when the screen, which I employed, is placed in front of the segment by which the image of *Sirius* is formed in the field of view, it is scarcely possible to distinguish the image of *Sirius* either in colour or apparent magnitude from that of either star of comparison.

Thus, although the parallax factor is only moderately great, the conditions for accurate measurement are extremely favourable.

For *Sirius* the proper motion may be deduced as follows:—According to NEWCOMB (Catalogue of 1098 Standard Clock and Fundamental Stars), the periodic terms (AUWERS') which should be applied to the positions of *Sirius* are:—

	P.	P′.
	s	″
1879·4	−0·086	−1·42
1880·4	− ·074	−1·44
1881·4	− ·061	−1·45
1882·4	− ·046	−1·44
1883·4	− ·030	−1·42

or developed in powers of the time from 1882·0.

$$P = -0^{s}{\cdot}0524 + 0^{s}{\cdot}0149\,(t - 1882{\cdot}0) + 0^{s}{\cdot}0007\,(t - 1882{\cdot}0)^2$$

$$P' = -1''{\cdot}447 + 0''{\cdot}010\,(t - 1882{\cdot}0) + 0''{\cdot}007\,(t - 1882{\cdot}0)^2$$

The absolute proper motion of *Sirius* from the same Catalogue is

$$\left.\begin{array}{l}\text{in R.A. } -0^{s}{\cdot}0373 \\ \text{in Dec. } -1''{\cdot}207\end{array}\right\} \text{ for } 1882{\cdot}0.$$

The combination of P and P′ with these numbers gives the following

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values of the proper motion of *Sirius* (expressed in seconds of arc of a great circle), and of the angle of position of this motion:—

1881·0	1″·238	in the direction	195°·80
1882·0	1·240	„ „	195·08
1883·0	1·221	„ „	194·34

When these motions are projected on the lines *Sirius*$-\alpha$ and *Sirius*$-\beta$, we obtain the following values expressed in semi-revolutions of the micrometer screw :—

	Star α.	Star β.
	R	R
1881·0	+0·0398	−0·0608
1882·0	+ ·0409	− ·0618
1883·0	+ ·0414	− ·0618

and these motions have been employed in the after reductions.

The following are, so far as I know, all the existing Meridian observations of the comparison stars ; their proper motions, obviously very small, have been neglected in the reductions:—

	Epoch.	Equinox 1882·0.		No. of Obs.
		α.		
		h m s	° ′ ″	
Lalande 12936	1800	6 36 41·44	−15 53 45·23	1
Arg. Oeltz. 5511 ...	1850	41·58	44·19	2
„ „ 5512 ...				
Cape Merid. Observations	1882·20	41·564	41·38	9
		β.		
		h m s	° ′ ″	
Lalande 13129		6 42 22·32	−17 22 50·43	2
„ 13130				
Arg. Oeltz. 5676 ...		22·54	47·92	1
Cape Merid. Observations	1882·18	22·375	49·79	11

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The following Table contains the results of all the measures which I have made in course of this investigation.

Results which depend on a *half set* of observations are indicated in the Table. The whole of these observations, with the exception of Nos. 7, 30, and 38, have been employed in the after computations ; the exclusion of the three observations in question in no way affects the final result, but depends on an agreement between ELKIN and myself, viz. that observations made in conditions of image less favourable than those indicated by the figure 3 would not probably conduce to the truth of the final result, and, therefore, should in no case be employed ; latterly we abstained from observing in such circumstances.

The columns marked α and β contain the direct results of the Heliometer readings obtained in measuring the distance of *Sirius* from the stars α and β respectively, corrected for Screw Error, Run, Refraction, Proper Motion, and Aberration.

The column marked $\alpha-\beta+\Delta D$ gives the corrected difference of these distances, obtained as follows:—

Since the position angles of *Sirius* from the two comparison stars differ sensibly from 180°, the sum of the distances is affected to a small extent by the parallax of *Sirius*.

From a rough preliminary solution an approximate value of this parallax ($0^R\cdot0311$) was obtained, and, therefore, a correction of

$$-0^R\cdot0065 \,.\, R \,.\, \cos\,(\odot - 157^\circ\cdot6)$$

was applied to the sums of the distances.

A mean value of the sums so obtained was then adopted, and the difference of any particular sum from the mean sum was considered to be due (apart from accidental errors of observation) to difference of the instantaneous scale value from the mean.

If

S_0 = the mean sum of the distances $= 568^R\cdot4518$.
S = any observed sum of the distances.
D_0 = the mean difference of the distances $= 4\cdot3173$.
D = any observed difference of the distances.
ΔD = the correction to be applied to the observed difference.

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then

$$\Delta D = (S_o - S) \times \frac{D}{S},$$

or practically

$$\Delta D = (S_o - S) \frac{D_o}{S_o} = 0{\cdot}0076\ (S_o - S).$$

The largest value of this correction, ΔD, occurs in the case of observation No. 31 (March 5, 1882), when it amounts to $-0^R{\cdot}0008 = -0''{\cdot}01$; in general it is absolutely insignificant.

Observations.

Rotation No.	Date.	Sidereal Time.	Definition.		Temperature—F.	α	β	$\alpha - \beta + \Delta D$
			Images.	Steadiness.				
	1881	h m			°	R	R	R
1	Aug. 29	3 6	1-2	1-2	50·4	286·3859	282·0323	4·3539
2	Sept. 5	3 16	1-2	2-3	45·2	·3859	·0423	·3438
3	14	4 28	3	3	49·5	·4006	·0467	·3540
4	20	3 35	1	1-2	54·7	·4045	·0379	·3667
5	23	4 25	3	3	57·5	·3912	·0325	·3590
6	27	3 57	2	2-3	57·7	·4245	·0598	·3645
7	30	4 7	3-4	3	54·0	·3837	·0272	[·3588] ½ set
8	Oct. 4	4 43	1-2	1-2	55 0	·3959	·0589	·3370
9	8	5 35	2	2-3	50·5	·4394	·0749	·3641
10	16	3 20	1-2	1-2	59·3	·4016	·0313	·3705
11	19	4 40	1-2	1-2	60·5	·4139	·0448	·3691
12	28	5 38	1-2	2	47·3	·3996	·0403	·3594
13	Nov. 3	3 25	2-3	2-3	59·5	·4181	·0224	·3958
14	5	3 49	—	—	58·8	·4043	·0333	·3711
15	13	3 25	2	2-3	46·0	·4016	·0455	·3562
16	18	4 41	2	2	51·8	·4158	·0475	·3682
17	25	2 58	2-3	2-3	61·7	·3996	·0388	·3607
18	28	4 41	2-3	2-3	55·7	·4502	·0882	·3614
19	Dec. 8	3 42	1-2	2-3	54·0	·4132	·0436	·3696 ½ set
20	9	4 52	2-3	2-3	60·5	·4195	·0805	·3385
21	11	3 49	2	3	62·0	·4506	·0686	·3715
22	16	4 4	2-3	3	59·8	·4309	·0674	·3631
23	23	3 48	2	2-3	64·0	·4317	·0517	·3797
24	29	4 23	2-3	2-3	66·3	·3940	·0629	·3310

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Observations—continued.

Rotation No.	Date.	Sidereal Time.	Definition.		Temperature—F.	α	β	α − β + Δ D
			Images.	Steadiness.				
	1882	h m			°	R	R	R
25	Jan. 7	4 0	1–2	2	60·8	286·3974	282·0496	4·3478
26	10	3 5	1	1–2	61·0	·3756	·0386	·3373
27	19	4 34	2	2–3	63·3	·4052	·0758	·3291
28	Feb. 16	9 7	1–2	1–2	61·5	·3817	·1100	·2713
29	24	9 35	2	2	58·3	·3838	·0893	·2943
30	27	9 19	3–4	3–4	64·3	·3610	·0794	[·2816] ½ set
31	March 5	10 28	2–3	2–3	65·0	·3840	·0801	·3038
32	10	9 25	3	3	67·0	·3834	·0741	·3092
33	15	10 29	1–2	2–3	63·5	·3692	·0714	·2978
34	18	9 35	3	3	64·3	·3680	·0547	·3135
35	20	9 3	2	2	63·8	·3612	·0799	·2813
36	24	9 7	2	2	64·0	·3682	·0896	·2785
37	April 1	9 48	2	2–3	63·3	·3931	·0924	·3004
38	3	9 35	3–4	3–4	62·0	·3326	·1097	[·2229]
39	5	9 42	2–3	3	56·8	·3828	·1148	·2676
40	7	9 43	3	3	63·5	·3676	·0980	·2695
41	10	9 46	1–2	2–3	58·5	·3494	·0796	·2699
42	18	9 44	2	2–3	61·0	·3554	·0776	·2779
43	19	10 18	3	3	60·3	·3579	·1049	·2529 ½ set
44	22	9 45	3	3	57·0	·3693	·0757	·2936
45	25	9 12	2	2–3	61·3	·3456	·0826	·2632
46	26	10 5	1–2	1–2	62·0	·3340	·0665	·2679 ½ set
47	28	9 9	1–2	1–2	60·0	·3353	·0746	·2610
48	May 2	9 53	2–3	3	56·7	·3330	·0713	·2620
49	3	9 57	2–3	2–3	56·5	·3504	·0717	·2789
50	5	9 42	3	3	61·5	·3278	·0654	·2628 ½ set
51	8	10 12	2	2–3	60·0	·3310	·0681	·2633 ½ set
52	18	10 10	2–3	2–3	52 8	·3531	·0891	·2641
53	19	9 58	2–3	2–3	56·3	·3555	·0904	·2651
54	21	10 15	2	2–3	54·7	·3383	·0522	·2866
55	23	10 0	2	2–3	55·5	·3786	·0698	·3088 ½ set
56	27	10 12	3	3	60·4	·3049	·0536	·2520 ½ set
57	Aug. 3	2 36	2	3	53·0	·3727	·0669	·3059
58	4	2 26	2–3	3	43·3	·3784	·0587	·3199
59	7	2 36	2–3	2–3	48·0	·3908	·0714	·3194
60	19	2 38	3	3	51·5	·3878	·0573	·3306
61	Nov. 9	4 13	1–2	1–2	54·5	·4292	·0555	·3735 ½ set

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Observations—continued.

Rotation No.	Date.	Sidereal Time.	Definition.		Temperature—F.	α	β	α−β+ΔD
			Images.	Steadiness.				
	1882	h m			°	R	R	R
62	Nov. 16	2 47	1-2	1-2	55·5	286·3832	282·0169	4·3667
63	23	3 23	1	1	55·8	·3960	·0288	·3674
64	24	3 33	3	3	59·5	·4125	·0675	·3448
65	25	2 42	2-3	2-3	60·5	·3975	·0446	·3530
66	27	3 36	2-3	2-3	62·0	·4081	·0551	·3529
67	28	3 41	2-3	2-3	64·0	·4102	·0596	·3505
68	Dec. 3	3 9	1-2	2	60·0	·4076	·0537	·3538
69	4	3 28	1-2	1-2	58·7	·3955	·0266	·3691
70	18	3 45			70·0	·4143	·0562	·3579
71	24	3 19	2-3	2-3	56·8	·4077	·0565	·3511
72	24	9 57	2-3	2-3	56·5	·3940	·0466	·3475
73	1883 Feb. 20	9 35	1-2	1-2	64·7	·3952	·0822	·3128
74	21	8 50			60·0	·3684	·0725	·2959 ½ set
75	March 3	10 5	2	2	66·5	·3689	·0764	·2925
76	4	9 59			67·3	·3664	·0831	·2833
77	April 30	10 36	2-3	3	58·3	·3683	·1201	·2479
78	May 8	9 20	1	2	67·0	·3687	·1074	·2611 ½ set
79	12	9 48			54·5	·3540	·1098	·2441
80	13	9 12	1-2	1-2	58·5	·3734	·0879	·2854 ½ set
81	19	9 55	2	2	51·8	·3870	·1311	·2554
82	20	10 11	3	3	53·0	·3667	·1082	·2583

Assuming the true value of $\alpha-\beta$ for 1882·0 to be

$$= {}^{R}4{\cdot}3173 + \begin{cases} x_E & \text{if East of Meridian} \\ x_W & \text{if West of } \quad \text{,,} \end{cases}$$

also putting the annual variation of $\alpha-\beta$, due to an error in the assumed proper motion of *Sirius*, or to proper motion in one or both of the comparison stars

$$= y,$$

and the (Parallax of *Sirius*) × 1·695

$$= z,$$

we obtain from the observations the following equations of condition:—

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Equations of Condition.

Rotation No.		I.		II.	
		v	p	v	p
	R				
1	$1{\cdot}000x_E - {\cdot}341y + {\cdot}415z = +0{\cdot}037$	+·010		+·010	
2	$1{\cdot}000x_E - {\cdot}322 + {\cdot}521 + {\cdot}027$	−·005		−.005	
3	$1{\cdot}000x_E - {\cdot}297 + {\cdot}641 + {\cdot}037$	−·001		−·001	½
4	$1{\cdot}000x_E - {\cdot}281 + {\cdot}717 + {\cdot}049$	+·008		+·007	
5	$1{\cdot}000x_E - {\cdot}272 + {\cdot}752 + {\cdot}042$	−·001		−·001	½
6	$1{\cdot}000x_E - {\cdot}262 + {\cdot}795 + {\cdot}047$	+·002		+·002	
8	$1{\cdot}000x_E - {\cdot}243 + {\cdot}860 + {\cdot}020$	−·028		−·028	
9	$1{\cdot}000x_E - {\cdot}232 + {\cdot}893 + {\cdot}047$	−·002		−·003	
10	$1{\cdot}000x_E - {\cdot}210 + {\cdot}943 + {\cdot}053$	+·001		+·001	
11	$1{\cdot}000x_E - {\cdot}202 + {\cdot}958 + {\cdot}052$	·000		−·001	
12	$1{\cdot}000x_E - {\cdot}176 + {\cdot}986 + {\cdot}042$	−·012		−·012	
13	$1{\cdot}000x_E - {\cdot}161 + {\cdot}991 + {\cdot}079$	+·025		+·025	
14	$1{\cdot}000x_E - {\cdot}155 + {\cdot}990 + {\cdot}054$	+·000		·000	
15	$1{\cdot}000x_E - {\cdot}133 + {\cdot}976 + {\cdot}039$	−·014		−·014	
16	$1{\cdot}000x_E - {\cdot}120 + {\cdot}958 + {\cdot}051$	−·001		−·001	
17	$1{\cdot}000x_E - {\cdot}101 + {\cdot}919 + {\cdot}044$	−·006		−·006	
18	$1{\cdot}000x_E - {\cdot}092 + {\cdot}898 + {\cdot}044$	−·005		−·005	
19	$1{\cdot}000x_E - {\cdot}065 + {\cdot}813 + {\cdot}052$	+·008	½	+·007	½
20	$1{\cdot}000x_E - {\cdot}062 + {\cdot}802 + {\cdot}021$	−·023		−·023	
21	$1{\cdot}000x_E - {\cdot}057 + {\cdot}780 + {\cdot}054$	+·011		+·011	
22	$1{\cdot}000x_E - {\cdot}043 + {\cdot}723 + {\cdot}046$	+·006		+·006	
23	$1{\cdot}000x_E - {\cdot}024 + {\cdot}636 + {\cdot}062$	+·027		+·026	
24	$1{\cdot}000x_E - {\cdot}008 + {\cdot}551 + {\cdot}014$	−·017		−·017	
25	$1{\cdot}000x_E + {\cdot}018 + {\cdot}416 + {\cdot}031$	+·007		+·006	
26	$1{\cdot}000x_E + {\cdot}025 + {\cdot}370 + {\cdot}020$	−·002		−·002	
27	$1{\cdot}000x_E + {\cdot}050 + {\cdot}220 + {\cdot}012$	−·003		−·003	
28	$1{\cdot}000x_W + {\cdot}127 - {\cdot}268 - {\cdot}046$	−·036		[−·037]	
29	$1{\cdot}000x_W + {\cdot}149 - {\cdot}398 - {\cdot}023$	−·007		−·007	
31	$1{\cdot}000x_W + {\cdot}174 - {\cdot}536 - {\cdot}014$	+·009		+·009	
32	$1{\cdot}000x_W + {\cdot}187 - {\cdot}606 - {\cdot}008$	+·019		+·019	½
33	$1{\cdot}000x_W + {\cdot}201 - {\cdot}674 - {\cdot}020$	+·010		+·010	
34	$1{\cdot}000x_W + {\cdot}209 - {\cdot}712 - {\cdot}004$	+·028		+·028	½
35	$1{\cdot}000x_W + {\cdot}215 - {\cdot}736 - {\cdot}036$	−·003		−·003	
36	$1{\cdot}000x_W + {\cdot}226 - {\cdot}782 - {\cdot}039$	−·004		−·003	
37	$1{\cdot}000x_W + {\cdot}248 - {\cdot}862 - {\cdot}017$	+·022		+·023	
39	$1{\cdot}000x_W + {\cdot}258 - {\cdot}894 - {\cdot}050$	−·009		−·009	
40	$1{\cdot}000x_W + {\cdot}264 - {\cdot}910 - {\cdot}048$	−·006		−·006	½
41	$1{\cdot}000x_W + {\cdot}272 - {\cdot}931 - {\cdot}047$	−·004		−·004	
42	$1{\cdot}000x_W + {\cdot}204 - {\cdot}975 - {\cdot}039$	+.006		+·007	

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Equations of Condition—continued.

Rotation No.		I.		II.	
		v	p	v	p
43	$1{\cdot}000x_W + {\cdot}297y - {\cdot}979z = -$ R $0{\cdot}064$	$-{\cdot}019$	$\frac{1}{2}$	$-{\cdot}018$	$\frac{1}{4}$
44	$1{\cdot}000x_W + {\cdot}305 - {\cdot}990 - {\cdot}024$	$+{\cdot}022$		$+{\cdot}022$	$\frac{1}{2}$
45	$1{\cdot}000x_W + {\cdot}313 - {\cdot}998 - {\cdot}054$	$-{\cdot}008$		$-{\cdot}007$	
46	$1{\cdot}000x_W + {\cdot}316 - 1{\cdot}001 - {\cdot}049$	$-{\cdot}002$	$\frac{1}{2}$	$-{\cdot}002$	$\frac{1}{2}$
47	$1{\cdot}000x_W + {\cdot}321 - 1{\cdot}005 - {\cdot}056$	$-{\cdot}009$		$-{\cdot}009$	
48	$1{\cdot}000x_W + {\cdot}332 - 1{\cdot}008 - {\cdot}055$	$-{\cdot}008$		$-{\cdot}008$	
49	$1{\cdot}000x_W + {\cdot}335 - 1{\cdot}009 - {\cdot}038$	$+{\cdot}009$		$+{\cdot}009$	
50	$1{\cdot}000x_W + {\cdot}340 - 1{\cdot}008 - {\cdot}055$	$-{\cdot}008$	$\frac{1}{2}$	$-{\cdot}007$	$\frac{1}{4}$
51	$1{\cdot}000x_W + {\cdot}349 - 1{\cdot}006 - {\cdot}054$	$-{\cdot}007$	$\frac{1}{2}$	$-{\cdot}007$	$\frac{1}{2}$
52	$1{\cdot}000x_W + {\cdot}376 - {\cdot}977 - {\cdot}053$	$-{\cdot}007$		$-{\cdot}007$	
53	$1{\cdot}000x_W + {\cdot}379 - {\cdot}973 - {\cdot}052$	$-{\cdot}006$		$-.006$	
54	$1{\cdot}000x_W + {\cdot}384 - {\cdot}963 - {\cdot}031$	$+{\cdot}014$		$+{\cdot}015$	
55	$1{\cdot}000x_W + {\cdot}390 - {\cdot}953 - {\cdot}009$	$+{\cdot}036$	$\frac{1}{2}$	[$+{\cdot}037$]	
56	$1{\cdot}000x_W + {\cdot}401 - {\cdot}928 - {\cdot}065$	$-{\cdot}021$	$\frac{1}{2}$	$-{\cdot}021$	$\frac{1}{4}$
57	$1{\cdot}000x_E + {\cdot}588 - {\cdot}016 - {\cdot}011$	$-{\cdot}010$		$-.010$	
58	$1{\cdot}000x_E + {\cdot}591 + {\cdot}000 + {\cdot}003$	$+{\cdot}004$		$+{\cdot}003$	
59	$1{\cdot}000x_E + {\cdot}599 + {\cdot}051 + {\cdot}002$	${\cdot}000$		${\cdot}000$	
60	$1{\cdot}000x_E + {\cdot}632 + {\cdot}252 + {\cdot}013$	$+{\cdot}002$		$+{\cdot}001$	$\frac{1}{2}$
61	$1{\cdot}000x_E + {\cdot}856 + {\cdot}986 + {\cdot}056$	$+{\cdot}011$	$\frac{1}{2}$	$+{\cdot}010$	$\frac{1}{2}$
62	$1{\cdot}000x_E + {\cdot}875 + {\cdot}967 + {\cdot}049$	$+{\cdot}005$		$+{\cdot}004$	
63	$1{\cdot}000x_E + {\cdot}894 + {\cdot}933 + {\cdot}050$	$+{\cdot}008$		$+{\cdot}007$	
64	$1{\cdot}000x_E + {\cdot}897 + {\cdot}927 + {\cdot}028$	$-{\cdot}014$		$-{\cdot}015$	$\frac{1}{2}$
65	$1{\cdot}000x_E + {\cdot}899 + {\cdot}921 + {\cdot}036$	$-{\cdot}005$		$-{\cdot}006$	
66	$1{\cdot}000x_E + {\cdot}905 + {\cdot}907 + {\cdot}036$	$-{\cdot}005$		$-{\cdot}006$	
67	$1{\cdot}000x_E + {\cdot}908 + {\cdot}900 + {\cdot}033$	$-{\cdot}007$		$-{\cdot}008$	
68	$1{\cdot}000x_E + {\cdot}921 + {\cdot}861 + {\cdot}037$	$-{\cdot}001$		$-{\cdot}002$	
69	$1{\cdot}000x_E + {\cdot}924 + {\cdot}853 + {\cdot}052$	$+{\cdot}014$		$+{\cdot}013$	
70	$1{\cdot}000x_E + {\cdot}962 + {\cdot}704 + {\cdot}041$	$+{\cdot}011$		$+{\cdot}010$	
71	$1{\cdot}000x_E + {\cdot}979 + {\cdot}627 + {\cdot}034$	$+{\cdot}007$		$+{\cdot}007$	
72	$1{\cdot}000x_W + {\cdot}979 + {\cdot}626 + {\cdot}030$	$+{\cdot}003$		$+{\cdot}003$	
73	$1{\cdot}000x_W + 1{\cdot}138 - {\cdot}329 - {\cdot}005$	$+{\cdot}016$		$+{\cdot}016$	
74	$1{\cdot}000x_W + 1{\cdot}141 - {\cdot}346 - {\cdot}021$	$+{\cdot}001$	$\frac{1}{3}$	$+{\cdot}001$	$\frac{1}{2}$
75	$1{\cdot}000x_W + 1{\cdot}168 - {\cdot}488 - {\cdot}025$	$+{\cdot}004$		$+{\cdot}004$	
76	$1{\cdot}000x_W + 1{\cdot}171 - {\cdot}517 - {\cdot}034$	$-{\cdot}004$		$-{\cdot}004$	
77	$1{\cdot}000x_W + 1{\cdot}327 - 1{\cdot}007 - {\cdot}069$	$-{\cdot}014$		$-{\cdot}014$	
78	$1{\cdot}000x_W + 1{\cdot}349 - 1{\cdot}006 - {\cdot}056$	$-{\cdot}001$	$\frac{1}{2}$	$-{\cdot}001$	$\frac{1}{2}$
79	$1{\cdot}000x_W + 1{\cdot}360 - {\cdot}998 - {\cdot}073$	$-{\cdot}018$		$-{\cdot}018$	
80	$1{\cdot}000x_W + 1{\cdot}362 - {\cdot}995 - {\cdot}032$	$-{\cdot}023$	$\frac{1}{2}$	$+{\cdot}023$	$\frac{1}{2}$
81	$1{\cdot}000x_W + 1{\cdot}379 - {\cdot}974 - {\cdot}062$	$-{\cdot}008$		$-{\cdot}008$	
82	$1{\cdot}000x_W + 1{\cdot}381 - {\cdot}970 - {\cdot}059$	$-{\cdot}005$		$-{\cdot}005$	$\frac{1}{2}$

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The existence of a very marked parallax seems to be evident at a glance, the sign of the absolute term being, in every case, the same as that of the coefficient of z.

Giving half weight to those equations which depend on "half sets" of observations, the resulting normal equations are the following:—

$$\begin{aligned} 73{\cdot}500x &+ 26{\cdot}711y + 2{\cdot}531z = +0{\cdot}226 \\ 26{\cdot}711 &+ 27{\cdot}953 - 8{\cdot}258 - {\cdot}511 \\ 2{\cdot}531 &- 8{\cdot}258 + 47{\cdot}454 + 2{\cdot}368 \end{aligned}$$

Their solution and the substitution of the resulting values of x, y, and z give

$$[p.vv] = 0{\cdot}0114, \qquad \epsilon^2 = 0{\cdot}000145.$$

	R	p		R
$x =$	$+0{\cdot}0044$	45·6	Probable error $\pm$	$0{\cdot}0012$
y	$-{\cdot}0083$	16·5	„	·0020
z	$+{\cdot}0483$	42·7	„	·00126

$$\pi = +0''{\cdot}367 \pm 0''{\cdot}0096,$$

and the probable error of one observation is $\pm 0^{R}{\cdot}00826 \pm 0''{\cdot}106$. I have endeavoured to estimate the relative weight to be given to observations made under the different conditions of quality of images and steadiness of definition, but the following Table will show that these two conditions cannot be separated.

Steadiness of the air.	Quality of image.					Not described.	Rejected 3-4.
	1	1-2	2	2-3	3		
	No. of obs.	No. of obs.	No. of obs.	No. of obs.	No. of obs.	No. of obs.	No. of obs.
1	1						
1-2	2	12					
2	1	3	6				
2-3		4	11	15			
3			2	5	12		
Undescribed						5	3

It appears best therefore to divide the observations into groups according to quality of the images, and the following Tables give the "*mean square of the residuals*" (ϵ^2) in each group. Also to test whether the different conditions

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of images exert any systematic influence on the measures, I give in the same Table the *mean value of the residuals* (v_0) in each group.

Images.	No. of obsrvtns.	ϵ^2	v_0	ϵ_0
1 and 1–2	23	0·000143	−·0007	±·0025
2	19	145	−·0024	·0028
2–3	20	115	+·0027	·0024
3	12	192	−·0014	·0040

The conclusion is that the accuracy of observation is very slightly influenced by the quality of the images, except in the very worst circumstances, and that different qualities of definition exercise little or no systematic influence on the absolute results.

We arrive at a similar conclusion if we reject all observations whose residuals amount to three times the probable error—viz. reject all observations differing $\pm^{R}$·024 from the mean of the whole:—

Images.	1 and 1–2	2	2–3	3
ϵ^2	R ·000087	R ·000083	R ·000088	R ·000143
No. of obs. rejected	1	2	1	1

It is remarkable indeed that much the largest error (-0^{R}·037. Feb. 16–Number 28) results from observations made on a night of particularly fine definition. I can find no reason for such an error. The following are the separate measures for the night in question:—

Star α.		Star β.	
h m	R	h m	R
8 40·0	286·415	8 31·2	282·112
8 49·8	·388	9 0·9	·099
9 21·9	·412	9 9·7	·113
9 34·6 *	·396	9 50·0	·146

There is a note attached to the measure marked *, which states that the air was more unsteady during the time when this measures was made; and I

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appear, in consequence, to have spent more time than usual over these two bisections; but there is no such discordance among the separate observations as to create the suspicion of a mistaken reading. There seems therefore *à priori* to be no legitimate ground for rejecting this or indeed any of the other observations.

We shall probably approximate very closely to the truth by giving *half weight* to complete observations made with images 3, and to all others weight *unity*.

But before applying any other criterion for the rejection of outstanding observations, it is well to consider whether there are possible systematic errors to which the observations may be liable.

Most conceivable sources of error entirely disappear in the present case if my estimate of the similarity of apparent magnitude, colour, and consequently of mean refrangibility of the light, of both comparison stars with *Sirius* (viewed through the screen) is correct. Still it is necessary to consider those errors which may depend on the angle made by the line joining the comparison stars with the vertical—that is, on $(p-q)$—and possibly also those errors which depend on the zenith distance, though I must confess that if either of such errors are found to exist in the present case, I should be puzzled to account for their origin. The actual observations have been confined within the following limits:—

	Hour Angle. h m		h m
East of Meridian	1 57	to	4 14
West „	2 10*	to	4 0

and we have

Hour Angle. h m	East of Meridian. $(p-q)$.	West of Meridian. $p-q$.
2 0	268	8
2 30	263	13
3 0	260	16
3 30	259	17
4 0	258	18

* There is one exception (No. 9), when the Hour Angle E. was $1^h\ 5^m$, but the observation is perfectly normal, the residual being $-0^R{\cdot}003 = -0''{\cdot}037$.

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That is, East of the Meridian the line joining the comparison stars is inclined from 2° to 12° from the horizontal, and West of the Meridian from 8° to 18° from the vertical. Thus, so far as errors depending on $p-q$ are concerned, we may divide the observations into two great classes—viz. those East and those West of the Meridian. Unfortunately, a like distinction separates the resulting equations; those having parallax factors with the + sign resulting as a rule from observations made East of the Meridian, and those with parallax factors having a — sign from observations West of the Meridian. It was my intention in December 1882 and January 1883, when *Sirius* culminates about midnight, to make a nearly simultaneous series of observations both East and West of the Meridian, but the state of my health compelled me to seek rest during the month of January, and it was too late to carry out my intention when I returned to the Observatory in the end of that month. Thus the only observations of the kind were made on December 24; but there remain in the changes from East to West, West to East, and finally East to West, and in the difference of the parallax factors, sufficient material to determine the parallax with considerable weight, even if we assume that the observations East of the Meridian differ systematically from those West of it.

It will be observed from a glance at the equations and the corresponding hour angles that the resulting parallax will be nearly free of any term depending on the zenith distance on the same side of the Meridian, as there is no systematic connection between the hour angle and parallax factor on the same side of the Meridian; but for the general interest of the question I have arranged the mean values of the residuals in the following groups:—

Hour Angle	h < 3	h h m 3 — 3 30	h > 3
East of Meridian	R + ·0006	R + ·0022	R − ·0010
No. of Observations ...	19	11	6
West of Meridian	+ ·0014	+ ·0011	− ·0030
No. of Observations ...	12	16	9

These differences are all within the limits of their probable errors, nor do they indicate any appearance of a law. Thus all the systematic errors to

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which this series of observations is liable can be thoroughly considered by merely writing for x in the equations of condition

x_E when the observation has been made East of the Meridian
x_W " " " West "

as has been done in the original formation of the equations.

This leads to the following normals giving half weight as before to the equations which depend on half sets of observations :—

$40{\cdot}000x_E$		$+\ 8{\cdot}268y$	$+28{\cdot}498z$	$=+1{\cdot}481$
	$+33{\cdot}500x_W$	$+18{\cdot}443$	$-25{\cdot}967$	$-1{\cdot}255$
$8{\cdot}268$	$+18{\cdot}443$	$+27{\cdot}953$	$-\ 8{\cdot}258$	$-0{\cdot}511$
$28{\cdot}498$	$-25{\cdot}967$	$-\ 8{\cdot}258$	$+47{\cdot}454$	$+2{\cdot}368$

and their solution to the following values and weights :—

	R	Weight.
x_E	$=+0{\cdot}0041$	10·0
x_W	$+\ {\cdot}0047$	7·4
y	$-\ {\cdot}0083$	16·1
z	$+\ {\cdot}0487$	7·0

These values are practically identical with those from the first solution, in which x is supposed $=x_W=x_E$, and the substitution of these values in the equations of condition leads, in no case, to residuals differing $0^R{\cdot}001$ from those of the previous solution.

The difference

$$x_W - x_E = {}^R0{\cdot}0006\ (= 0''{\cdot}007)$$

is much smaller than its probable error, and we may consider that, so far as this investigation can decide the question, the observations are entirely free from systematic error.

If we regard six equations as doubtful (8, 13, 23, 28, 34, 55), the limit of error, according to PIERCE's criterion, is

$${}^R0{\cdot}027.$$

In the following final solution, only equations 28 and 55 have been rejected.

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Equations 19, 46, 51, 61, 74, 78, 80, which depend on half sets of observations, have received half weight.

Equations 3, 5, 32, 34, 40, 44, 60, 64, 82, receive half weight, because they were made under unfavourable circumstances of definition (Images 3), see p. 94.

Equations 43, 50, 56 have received $\frac{1}{4}$ weight because they depend on half sets of observations made with Images 3.

The normals in this final discussion then become

$$\begin{aligned} 66{\cdot}75x &+ 24{\cdot}48y + 4{\cdot}81z = +0{\cdot}334 \\ 24{\cdot}48 &+ 26{\cdot}01 - 7{\cdot}01 \quad -0{\cdot}441 \\ 4{\cdot}81 &- 7{\cdot}01 + 43{\cdot}46 \quad +2{\cdot}199 \end{aligned}$$

and their solution, with the substitution of the values of the unknowns in the original equations, leads to the following results :—

$$(p.vv) = 0{\cdot}008253, \qquad \varepsilon^2 = 0{\cdot}0001115.$$

$x =$	$+0{\cdot}0044$,	Weight 40·6,	Probable error $\pm^{R}$	$0{\cdot}0011$
y	$-\ {\cdot}0079$,	,, 15·3,	,,	·0018
z	$+\ {\cdot}0488$,	,, 38·6,	,,	·00115

The resulting parallax is

$$\pi = +\,0''{\cdot}370 \pm 0''{\cdot}009,$$

and the probable error of *one* observation of the *difference* of the distances α and β is

$$\pm^{R}\,0{\cdot}0071 = \pm\,0''{\cdot}092.$$

The representation of this solution is given in Column II. adjoining the original equations, and graphically in Plate IV.

§ 6. *Parallax of Sirius.* Elkin.

The observations which I have made of *Sirius* and the comparison stars *a* and *b*, and which are to be discussed in the present section, consist of two distinct series. The first of these, comprising 60 observations, extends from March 11, 1881, to March 21, 1882, and was intended to be distributed

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pretty evenly over this period. It will be found that, with a few exceptions, this has been fairly attained. These exceptions are briefly: (1) in April 1881 there are a larger number of observations than usual, which were made to discover, if possible, the source of the somewhat large discordances of the first observations in March 1881 ; these April observations, however, agreed very fairly among themselves, and the discrepancies in question were set down to the account of my comparative inexperience. (2) The few clear evenings in the early part of June 1881 were devoted to the bright Comet then visible, and after that, and during July, *Sirius* is so near the Sun, that the faint comparison stars are not visible at sufficient altitudes for good observations. Finally, the fewer observations in January 1882 are due principally to the bad definition which usually accompanies the South-East winds prevalent at that season of the year at the Cape.

The second series, 26 observations, consists mainly of two groups of observations near the two maxima of parallax in September 1882 and March 1883, with a few intermediate ones. This series differs from the first otherwise only in being made with a different screen for reducing the light of *Sirius*, the same scale divisions being used throughout.

The position of this pair of comparison stars, with respect to *Sirius*, was extremely symmetrical. The approximate distance and position angles being

Star.	Magnitude.	Distance.	Position Angle.
		R	° ′
a	$7\frac{3}{4}$	385·3	242 46
b	8	391·9	61 50
	Difference ...	6·6	180 56

The factor of parallax was also not unfavourable, amounting to

$$1{\cdot}818 \sin (\odot + 100^{\circ}{\cdot}2) \,.\, R$$

for the difference *Sirius-a*−*Sirius-b*.

Both these stars were observed by ARGELANDER in his Southern zones, and bear the numbers 5451 and 5753 in Oeltzen's Catalogue. The magnitudes, as given by ARGELANDER (on two different nights, however) are 8 and

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7 8 respectively. In reality there is but about $\frac{1}{4}$ magnitude of difference between them, and star *b* is the fainter. Their proper motions appear to be small, as will be seen from the following comparison between ARGELANDER'S places and the modern Cape observations.

		R.A. 1882·0.	Decl. 1882·0.
		h m s	° ′ ″
Star *a*	Argelander 1850	6 34 49·79	−17 11 8·2
	Cape 1882 ...	49·95	12·3
Star *b*	Argelander 1850	6 45 5·34	−15 53 41·2
	Cape 1882 ...	5·45	40·0

The projection of the proper motion of *Sirius*, derived, as in § 5, on the lines *Sirius-a* and *Sirius-b*, I find to be in semi-revolutions of the micrometer screw :

	Star *a*.	Star *b*.
	R	R
1881·0	−0·0679	+0·0667
1882·0	−0·0660	+0·0649
1883·0	−0·0641	+0·0630

The numbers I have actually used in the reductions differ slightly from these, being

	Star *a*.	Star *b*.
	R	R
1881·0	−0·0671	+0·0660
1882·0	−0·0654	+0·0642
1883·0	−0·0636	+0·0625

For these latter numbers the values

$$\overset{s}{-0{\cdot}0372}$$

$$\overset{''}{-1{\cdot}199}$$

for the absolute proper motion of *Sirius* were taken, which accounts for the greater part of the difference ; the most important part, the variation of the

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motion, is sensibly the same as in the rigid deduction from NEWCOMB and AUWERS' data.

The distances, *Sirius-a* and *Sirius-b*, are so nearly equal that I have used the same scale divisions for each distance. The difference, *Sirius-b*—*Sirius-a* is therefore measured by the micrometer screw alone, independent of the division errors of the scale. The accuracy of this difference will depend then, apart from the errors of observation, principally upon the accuracy of the run of the screw. This was, according to our programme, determined each night, and the resulting value applied, so that no systematic error could arise therefrom ; and as to the casual error, I find that the probable error thereby introduced amounts to $\pm 0''\cdot04$ for the difference *Sirius-b*—*Sirius-a*, which, although larger than originally supposed to be, is still of little consequence beside the inevitable errors of observation.

The results of the observations are contained in the following Table, the distances being already corrected for refraction, for aberration, the latter by the formulæ

$$\begin{array}{lll} & & \text{R} \\ \textit{Sirius-a} & \ldots \quad \ldots & +0\cdot0293 \sin (\odot + 256\cdot8) \\ \textit{Sirius-b} & \ldots \quad \ldots & +0\cdot0301 \sin (\odot + 258\cdot3) \end{array}$$

and reduced, when necessary, to the focal scale reading 9·50. The proper motion above mentioned is also applied ; the first series, Nos. 1 to 60, being reduced to 1882·0, and the second series, Nos. 61 to 86, to 1883·0.

Observations. Series I.

No.	Date.	Sid. Time.	Images.	Steadiness.	Temp.	*Sirius-a.*	*Sirius-b*
	1881	h m			°	R	R
1	March 11	9 49	2	2	73·0	385·286	391·944
2	12	10 6	2–3	3	65·6	·265	·916
3	16	9 57	1	2	56·7	·295	·862
4	18	9 22	1	2	56·9	·290	·883
5	24	9 52	3	3	59·1	·241	·892
6	30	9 37	1	2	58·3	·286	·959
7	April 2	9 55	1	1	54·2	·267	·886
8	4	10 59	3	3	59·8	·308	·937
9	6	9 56	2	2	61·9	·293	·890

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Observations. Series I.—continued.

No.	Date.	Sid. Time.	Images.	Steadiness.	Temp.	*Sirius-a.*	*Sirius-b.*
	1881	h m			°	R	R
10	April 7	9 4	2	2	58·3	385·280	391·897
11	9	9 33	2	2	58·0	·278	·878
12	10	9 15	2	2	56·0	·282	·882
13	12	9 30	2	2	58·5	·312	·900
14	14	9 20	2–3	3	53·5	·355	·965
15	20	9 16	2	2	54·8	·363	·948
16	21	9 50	2–3	2–3	59·2	·369	·968
17	24	10 13	2	2	64·7	·379	·977
18	May 18	10 6	3	3	54·9	·363	·907
19	19	10 5	3	3	55·2	·348	·915
20	20	10 11	3	3	53·9	·371	·909
21	21	10 26	3	3	53·3	·365	·895
22	Aug. 12	2 38	2	2	49·9	·335	·840
23	13	2 38	1–2	2	49·5	·339	·797
24	25	3 16	1–2	2	44·8	·302	·835
25	28	3 15	1–2	2	45·0	·370	·811
26	30	3 38	1–2	2	54·5	·314	·824
27	Sept. 3	4 22	1–2	2	45·0	325	·866 ¾ set
28	7	4 6	1–2	1–2	54·5	·381	·835
29	13	3 58	2	2	43·0	·349	·813
30	19	4 41	2	2	55·7	·316	·812
31	21	4 23	2–3	2–3	48·8	·353	·846
32	24	4 51	1–2	2	52·5	·402	·847
33	28	4 53	2	2	55·3	·377	·837
34	Oct. 8	3 20	1–2	2	54·5	·375	·889
35	12	3 4	3	3	58·5	·386	·800
36	19	2 46	1–2	2	60·0	·316	·851
37	28	3 41	1	1–2	47·3	·316	·838
38	30	3 28	1–2	2–3	47·0	·301	·808
39	Nov. 7	3 29	2–3	2–3	54·8	·338	·841
40	14	2 46	3	3	53·5	·370	·749
41	19	3 59	2	2	57·0	·297	·826
42	25	4 31	1–2	1–2	58·8	·318	·848

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Observations. Series I.—continued.

No.	Date.	Sid. Time.	Images.	Steadiness	Temp.	*Sirius-a.*	*Sirius-b.*
	1881	h m			°	R	R
43	Dec. 1	3 31	1–2	2	53·5	385·340	391·927
44	12	3 22	2–3	2–3	63·0	·338	·901
45	18	4 24	2–3	2–3	58·0	·335	·863
46	24	4 39	2–3	3	60·8	·309	·864
	1882						
47	Jan. 17	4 19	2	2	69·5	·311	·886
48	21	4 10	2	2	65·0	·290	·903
49	Feb. 6	10 4	3	3	58·5	·285	·875
50	17	10 16	2–3	2–3	62·5	·305	·877
51	19	9 46	2–3	2–3	71·5	·301	·913
52	26	9 49	3	3	63·0	·288	·936
53	March 6	9 56	2	2–3	56·0	·276	·917
54	8	10 21	2–3	2–3	57·0	·270	·911
55	13	9 46	2	2	61·0	·298	·883
56	14	10 2	2	2	58·5	·277	·890
57	15	9 7	1–2	1–2	64·5	·270	·869
58	16	10 8	1–2	2	60·0	·278	·921
59	20	10 39	3	3	63·3	·269	·898
60	21	10 58	2–3	3	63·5	·261	·910

Observations. Series II.

No.	Date.	Sid. Time.	Images.	Steadiness.	Temp.	*Sirius-a.*	*Sirius-b.*
	1882	h m			°	R	R
61	Sept. 1	2 17	2	2–3	44·0	385·305	391·922
62	3	4 3	2	2	49·0	·285	·924
63	8	3 38	2	2	52·0	·287	·944
64	25	4 22	2	1–2	51·0	·292	·918
65	27	4 37	2–3	2	50·0	·313	·918
66	28	4 4	2	2–3	51·0	·297	·954
67	30	4 0	1–2	1–2	49·5	·280	·899
68	Oct. 1	4 5	2–3	2–3	51·0	·256	·879 $\frac{3}{4}$ set
69	2	4 32	1–2	2	52·5	·310	·940

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Observations. Series II.—continued.

No.	Date.	Sid. Time.	Images.	Steadiness.	Temp.	*Sirius-a.*	*Sirius-b.*
	1883	h m			°	R	R
70	Jan. 28	4 39	2–3	2–3	72·0	385·223	391·965
71	29	4 26	2	2–3	76·0	·279	·986 ½ set
72	30	4 48	2–3	2–3	70·0	·242	·986 ½ set
73	Feb. 2	4 30	1–2	2	65·0	·283	·963 ½ set
74	4	4 33	2	2–3	64·0	·288	·991 ½ set
75	5	4 41	3	3	68·0	·260	·957 ½ set
76	7	4 53	2	2–3	66·0	·300	·970 ½ set
77	March 5	9 53	2–3	2–3	67·0	·259	·975
78	8	9 30	3	3	61·0	·236	·990
79	12	10 25	3	3	63·0	·247	·984
80	13	10 29	1–2	2–3	67·0	·226	·969
81	14	10 26	2–3	2–3	62·0	·245	·978
82	16	10 21	2–3	2–3	73·0	·228	·974
83	22	9 28	3	2–3	67·0	·243	·951
84	25	10 12	2–3	2	65·0	·211	·970
85	27	10 9	2–3	2–3	65·0	·242	·984
86	28	10 20	2–3	2–3	61·0	·230	·992

I proceed to discuss the differences, *Sirius-b*—*Sirius-a*, and the following Table contains the equations of condition they give rise to, x denoting, as usual, the correction to the assumed mean difference

$$\overset{R}{6{\cdot}5600} \text{ for } 1882{\cdot}0, \text{ and}$$
$$6{\cdot}6878 \text{ for } 1883{\cdot}0.$$

$+0^{R}{\cdot}1278$ being the assumed annual motion for this period; $y = 1{\cdot}818\,\pi$ and z is the correction to the assumed motion. For the absolute term I have taken the observed difference corrected for the difference of the sums from their mean value, for which I assume

$$\overset{R}{777{\cdot}200}.$$

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This correction, however, never amounts to 0″·02 in this case.* The column "Residuals" will be explained further on.

Equations of Condition.

No.	Series I.				Residuals.	
					I.	II.
				R	R	R
1	+1·0x	+0·993y	−0·806z	=+0·098	+0·040	+0·045
2	1·0	+0·993	−0·803	+0·090	+0·032	+0·037
3	1·0	+0·988	−0·793	+0·008	−0·050	−0·044
4	1·0	+0·985	−0·787	+0·032	−0·025	−0·020
5	1·0	+0·966	−0·771	+0·092	+0·036	[+0·041]
6	1·0	+0·938	−0·754	+0·112	+0·058	+0·063
7	1·0	+0·918	−0·746	+0·060	+0·007	+0·012
8	1·0	+0·906	−0·740	+0·069	+0·017	[+0·022]
9	1·0	+0·890	−0·735	+0·037	−0·014	−0·010
10	1·0	+0·884	−0·732	+0·057	+0·007	+0·011
11	1·0	+0·867	−0·727	+0·040	−0·009	−0·005
12	1·0	+0·858	−0·724	+0·040	−0·009	−0·005
13	1·0	+0·841	−0·718	+0·028	−0·020	−0·016
14	1·0	+0·823	−0·713	+0·050	+0·004	+0·007
15	1·0	+0·760	−0·697	+0·024	−0·018	−0·015
16	1·0	+0·747	−0·694	+0·038	−0·003	+0·000
17	1·0	+0·711	−0·686	+0·037	−0·002	+0·001
18	1·0	+0·379	−0·620	−0·016	−0·032	[−0·032]
19	1·0	+0·362	−0·617	+0·006	−0·009	[−0·009]
20	1·0	+0·346	−0·615	−0·023	−0·037	[−0·037]
21	1·0	+0·332	−0·612	−0·030	−0·043	[−0·043]
22	1·0	−0·883	−0·384	−0·054	+0·014	+0·006
23	1·0	−0·891	−0·381	−0·101	−0·032	−0·040
24	1·0	−0·967	−0·349	−0·026	+0·048	+0·039

* The formation of the absolute term is as follows, taking No. 1 as an example

$$(391\cdot944-385\cdot286)-6\cdot560-\frac{(385\cdot286+391\cdot944)-777\cdot200}{777\cdot200}\cdot 6\cdot560=+0\cdot098.$$

Some few discrepancies of one unit in the third decimal between the numbers of the "Observations" and those of the absolute term of the "Equations of Condition" arise from their all having been originally computed to four decimal places.

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Equations of Condition. Series I.—continued.

No.					Residuals.	
					I.	II.
				R	R	R
25	+1·0x	−0·981y	−0·340z	=−0·119	−0·044	−0·053
26	1·0	−0·987	−0·334	−0·049	+0·026	+0·018
27	1·0	−0·998	−0·323	−0·020	+0·056	+0·047
28	1·0	−1·003	−0·312	−0·107	−0·031	−0·040
29	1·0	−1·006	−0·296	−0·095	−0·018	−0·028
30	1·0	−0·995	−0·280	−0·063	+0·013	+0·004
31	1·0	−0·992	−0·274	−0·066	+0·010	+0·001
32	1·0	−0·978	−0·266	−0·115	−0·040	−0·049
33	1·0	−0·961	−0·255	−0·100	−0·026	−0·035
34	1·0	−0·896	−0·228	−0·046	+0·023	+0·015
35	1·0	−0·863	−0·217	−0·146	−0·079	[−0·088]
36	1·0	−0·797	−0·198	−0·025	+0·038	+0·030
37	1·0	−0·692	−0·173	−0·038	+0·018	+0·010
38	1·0	−0·667	−0·168	−0·053	+0·001	−0·006
39	1·0	−0·554	−0·146	−0·057	−0·011	−0·017
40	1·0	−0·451	−0·127	−0·181	−0·142	[−0·148]
41	1·0	−0·372	−0·113	−0·030	+0·004	−0·001
42	1·0	−0·272	−0·097	−0·030	−0·003	−0·008
43	1·0	−0·172	−0·080	+0·026	+0·047	+0·042
44	1·0	+0·020	−0·050	+0·003	+0·011	+0·008
45	1·0	+0·126	−0·033	−0·032	−0·031	−0·034
46	1·0	+0·230	−0·017	−0·005	−0·011	−0·013
47	1·0	+0·605	+0·048	+0·015	−0·016	−0·016
48	1·0	+0·658	+0·059	+0·054	+0·019	+0·020
49	1·0	+0·840	+0·102	+0·030	−0·018	[−0·016]
50	1·0	+0·926	+0·133	+0·012	−0·041	−0·039
51	1·0	+0·938	+0·138	+0·052	−0·002	0·000
52	1·0	+0·970	+0·157	+0·087	+0·031	[+0·033]
53	1·0	+0·991	+0·179	+0·082	+0·024	+0·027
54	1·0	+0·992	+0·185	+0·082	+0·024	+0·027
55	1·0	+0·993	+0·198	+0·024	−0·034	−0·031
56	1·0	+0·992	+0·201	+0·054	−0·004	−0·001

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Equations of Condition. Series I.—continued.

No.				Residuals.	
				I.	II.
			R	R	R
57	$+1.0x$	$+0.991y$	$+0.204z = +0.039$	-0.019	-0.016
58	1.0	+0.989	+0.206	+0.083	+0.025	+0.028
59	1.0	+0.981	+0.217	+0.069	+0.012	[+0.015]
60	1.0	+0.978	+0.220	+0.089	+0.032	+0.035
			Series II.		
61	$+1.0x$	$-0.992y$	$-0.331z = -0.071$	-0.012	-0.007
62	1.0	−0.994	−0.325	−0.048	+0.011	+0.016
63	1.0	−1.005	−0.311	−0.030	+0.029	+0.034
64	1.0	−0.976	−0.265	−0.062	−0.004	+0.001
65	1.0	−0.969	−0.259	−0.082	−0.024	−0.019
66	1.0	−0.963	−0.258	−0.031	+0.026	+0.031
67	1.0	−0.953	−0.251	−0.068	−0.012	−0.006
68	1.0	−0.947	−0.249	−0.064	−0.008	−0.003
69	1.0	−0.942	−0.246	−0.058	−0.002	+0.003
70	1.0	+0.747	+0.078	+0.054	+0.015	[+0.012]
71	1.0	+0.757	+0.081	+0.019	−0.020	[−0.024]
72	1.0	+0.768	+0.083	+0.057	+0.017	[+0.013]
73	1.0	+0.801	+0.091	−0.008	−0.050	[−0.054]
74	1.0	+0.820	+0.097	+0.014	−0.029	[−0.033]
75	1.0	+0.830	+0.100	+0.009	−0.034	[−0.038]
76	1.0	+0.849	+0.105	−0.019	−0.064	[−0.067]
77	1.0	+0.989	+0.176	+0.028	−0.024	−0.029
78	1.0	+0.993	+0.185	+0.066	+0.013	+0.008
79	1.0	+0.993	+0.196	+0.049	−0.004	−0.009
80	1.0	+0.992	+0.198	+0.055	+0.002	−0.002
81	1.0	+0.991	+0.201	+0.045	−0.007	−0.012
82	1.0	+0.989	+0.206	+0.058	+0.006	+0.001
83	1.0	+0.973	+0.223	+0.020	−0.031	−0.037
84	1.0	+0.962	+0.231	+0.072	+0.021	+0.026
85	1.0	+0.952	+0.237	+0.054	+0.004	−0.001
86	1.0	+0.948	+0.239	+0.075	+0.025	+0.020

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Before giving the solution of these equations, some remarks appear necessary. On running the eye down the right-hand side of the "Equations of Condition" of Series I. it will be seen at once that there is indubitable evidence of the existence of a large parallax. The signs of these absolute terms are the same as those of the factor of parallax, except in seven cases, and these only when this factor is small; the greatest value with contrary signs is 0·379, No. 18. At the same time it will be noticed that these terms run by no means smoothly, and that the discordances are much larger than in the previously discussed series of *α Centauri*, and, I may add, than will be found in my other pairs. As it was our practice to take out, roughly at least, the results of the observations soon after their being made, these discrepancies did not fail to attract my attention, and they and my first surmises as to their origin have been already referred to in connection with the observations in March and April 1881. It was, however, not until after I became aware of the result of the observations made in August and September 1881 that the true source of these errors was suspected. During this period the definition was generally exceptionally fine, and differences of 1″ which occur between observations on consecutive nights were, as mere errors of observation, simply out of the question. For instance, the separate measures on August 25 and August 28 are as follows, each figure being the mean of two bisections eliminating the index error, and reduced so as to make the sums of the distances identical ($777^{R}\cdot200$):—

August 25.		R	August 28.		R
Sirius—Star *a*	...	385·346	Sirius—Star *a*	...	385·391
		·324			·402
		·342			·364
		·319			·359
Sirius—Star *b*	...	391·857	Sirius—Star *b*	...	391·807
		·855			·807
		·870			·849
		·887			·822
Images 1–2, Steadiness *z*.			Images 1–2, Steadiness 2.		

Not one of the individual results on the one night encroaches upon the ground covered by those on the other night, and the conclusion appears inevitable that on the two nights a different mode of bisection of the central star, *Sirius* itself, must have been adopted. This once admitted, the cause of

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the discordance was easily found, and I have little hesitation in saying that this cause was the greater brilliancy of the image of *Sirius* as compared with those of the stars *a* and *b*. When I commenced the series there was some difficulty from an insufficient supply of wire gauge in constructing a screen for *Sirius*, and I contented myself with reducing it to the brilliancy of a star of the 7th magnitude, so that there was nearly a whole magnitude of difference between it and the comparison stars. This difference, though absolutely not so very great, is yet quite sufficient when the stars approach the limit of measurement in magnitude to render the observation difficult. The fainter star is not seen when brought up close to the brighter one, and for me the measure appears to be effected more by judging of the bisection of the larger star by the imaginary line joining the two positions which the smaller star occupied before and after the motion in position angle than by its having been seen to actually cross the brighter star centrally. It would seem that I have not been able to maintain from night to night any uniformity in the estimation of this imaginary bisection, and it is a matter of much regret that these considerations did not present themselves to me more forcibly at the commencement of the series. When they did so, a large portion of the work was completed, and it was held to be decidedly advisable to finish it as commenced, and not to impair the homogeneity of the series by then attempting to remedy matters. Indeed, as long as these fluctuations of the point observed could be considered as *casual*, and consequently tending to eliminate themselves from the mean of a number of observations, but little harm would be done beyond increasing the probable error of the parallax determination. But the far more serious question arose as to whether the neglect of the precaution of equalising the images of *Sirius* and the comparison stars had not introduced *systematic* error into the work. Before, however, entering upon this delicate question I will communicate the results of the various solutions I have made of the equations furnished by Series I. under the supposition of the freedom of the observations from any such systematic error.

In the first place, giving all the 60 observations equal weight, the normals are—

			R	
$+60{\cdot}00x$	$+12{\cdot}43y$	$-18{\cdot}38z$	$=+0{\cdot}092$	
$+12{\cdot}43$	$+41{\cdot}22$	$-5{\cdot}30$	$+2{\cdot}791$	$[nn]=0{\cdot}2674$
$-18{\cdot}38$	$-5{\cdot}30$	$+12{\cdot}79$	$-0{\cdot}128$	

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and their solution—

$$\begin{array}{llll} & \overset{R}{} & \overset{R}{} & \\ z = & +0\cdot0010 & \pm 0\cdot0088 & \text{or with } z = \overset{R}{0} \\ y & +\ \cdot0718 & \cdot0037 & \qquad y \quad +\ \cdot0718 \pm 0\cdot0037 \\ x & -\ \cdot0131 & \cdot0041 & \qquad x \quad -\ \cdot0134 \quad \cdot0030 \end{array}$$

$$\pi = 0''\cdot508 \pm 0''\cdot026 \qquad \pi = -0''\cdot508 \pm 0''\cdot026$$

Probable error, 1 obs. $\pm$ 0·302 Probable error, 1 obs. $\pm$ 0·298

This solution is vitiated to some extent by the results of the two observations, Nos. 35 and 40, which stand out widely from the others, and which were made in one respect under exceptional circumstances, being the only ones with "Images 3" East of the Meridian. Without them, we have for the normals and their solution—

$$\begin{array}{llll} +58\cdot00x & +13\cdot74y & -18\cdot04z & = +\overset{R}{0}\cdot419 \\ +13\cdot74 & +40\cdot27 & -\ 5\cdot55 & +2\cdot583 \quad [nn] = 0\cdot2133 \\ -18\cdot04 & -\ 5\cdot55 & +12\cdot73 & -0\cdot183 \end{array}$$

$$\begin{array}{llll} & \overset{R}{} & \overset{R}{} & \\ z = & +0\cdot0047 & \pm 0\cdot0071 & \text{or with } z = \overset{R}{0} \\ y & +\ \cdot0674 & \cdot0031 & \qquad y \quad +\ \cdot0672 \pm 0\cdot0031 \\ x & -\ \cdot0073 & \cdot0034 & \qquad x \quad -\ \cdot0087 \quad \cdot0026 \end{array}$$

$$\pi = 0''\cdot477 \pm 0''\cdot022 \qquad \pi = 0''\cdot475 \pm 0''\cdot022$$

Probable error, 1 obs. $\pm$ 0·245 Probable error, 1 obs. $\pm$ 0·243

The residuals which this last solution ($x = -0\cdot0087$, $y = +0\cdot0672$, $z = 0$) gives are those under Column I. beside the equations of condition. They may now be used to ascertain the relative exactitude of observations made under different atmospheric conditions. Using the "Images" I find—

Images.	1 and 1–2.	2.	2–3.	3.
No. of observations ...	18	18	13	11
Probable error, 1 obs....	0″·312	0″·169	0″·202	0″·494

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Grouped according to the "Steadiness," their results—

Steadiness.	1, 1–2, 2.	2–3.	3.
No. of observations	34	11	15
Probable error, 1 observation .	″0·299	″0·223	″0.498

But the two are hardly in any respect independent, as has been already pointed out. It is not a little remarkable that the best definition should give the larger probable error, and shows the anomalous character of the errors of observation. It would seem that down to the quality 2–3 the variations of the point of *Sirius* observed have had a preponderating influence over the mere errors of bisection; on the other hand, the larger values for the quality 3 are caused entirely by the two discordant observations Nos. 35 and 40. Without them we have for "Images 3," 0″·239, and "Steadiness 3," 0″·248, while the grouping together of all the qualities down to 2–3 gives "Images 1 to 2–3," 0″·243, "Steadiness 1–2 to 2–3," 0″·242 for the probable error of one observation. I give, therefore, beside the above solutions the two following, one in which all observations are used, those with "Images 3" receiving the weight $\frac{1}{4}$, which is approximately $=\frac{(0\cdot243)^2}{(0\cdot494)^2}$, and the other in which only those observations are used where the "Images" were at least 2-3. These solutions are—

All Observations—those with "Images 3," Weight $\frac{1}{4}$.

$$\begin{array}{rrrr} +51\cdot75x & +8\cdot85y & -15\cdot50z & =+0\cdot124 \\ +8\cdot85 & +36\cdot86 & -4\cdot10 & +2\cdot405 \\ -15\cdot50 & -4\cdot10 & +10\cdot69 & -0\cdot130 \end{array} \qquad [p.nn] = 0\cdot2056$$

$z = +0\cdot0008$	$\pm 0\cdot0077$	or with	$z =$	0	
$y +\ \cdot0675$	$\cdot0032$		$y +\ \cdot0675$	$\pm 0\cdot0032$	
$x -\ \cdot0081$	$\cdot0035$		$x -\ \cdot0084$	$\cdot0027$	
$\pi = ″0\cdot478$	$\pm ″0\cdot022$		$\pi = ″0\cdot478$	$\pm ″0\cdot022$	
Probable error, 1 obs.	$\pm 0\cdot244$		Probable error, 1 obs.	$\pm 0\cdot241$	

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Rejecting the Observations with "Images 3."

$$+49{\cdot}00x + 7{\cdot}66y - 14{\cdot}54z = +0{\cdot}135^{R}$$
$$+7{\cdot}66 \quad +35{\cdot}40 \quad -3{\cdot}70 \quad +2{\cdot}277 \quad [nn] = 0{\cdot}1850$$
$$-14{\cdot}54 \quad -3{\cdot}70 \quad +9{\cdot}99 \quad -0{\cdot}131$$

$z = +0{\cdot}0007^{R} \pm 0{\cdot}0080$ or with $z = 0$

y	+ ·0660	·0032	y	+ ·0660	± 0·0032
x	− ·0075	·0036	x	− ·0078	·0027

$\pi = 0''{\cdot}467 \pm 0''{\cdot}022$ $\qquad$ $\pi = 0''{\cdot}467 \pm 0''{\cdot}022$

Probable error, 1 obs. ± 0·244 $\qquad$ Probable error, 1 obs. ± 0·241

All these solutions are practically identical; the proper motion correction comes out very small in all, and the parallax which this series gives—always under the hypothesis of its freedom from systematic error—may be taken—

$$0''{\cdot}47 \pm 0''{\cdot}022.$$

To revert to this question of possible systematic error. On looking down the column "Sidereal Times of Observation," it will be seen that nearly all the observations were made at hour angles from 2^h to 4^h both East and West of the Meridian. None were made nearer the Meridian than $1\frac{1}{2}^h$ on account of the inconvenient position in observing at small zenith distances, and none further than 5^h. During this interval the inclination of the line joining the stars to the vertical remains nearly constant, as will be seen from the following Table, which gives the values of $p-q$ for the different hour angles and sidereal times, q being the parallactic angle and p the position angle of the line in question—taken = 62°·3 :—

Hour Angle.	East.		West.	
	Sidereal Time.	$p-q$.	Sidereal Time.	$p-q$.
h	h m	°	h m	°
5	1 40	182·9	11 40	301·7
4½	2 10	182·4	11 10	302·2
4	2 40	182·4	10 40	302·2
3½	3 10	183·1	10 10	301·5
3	3 40	184·4	9 40	300·2
2½	4 10	186·9	9 10	297·7
2	4 40	190·9	8 40	293·7
1½	5 10	197·3	8 10	287·3

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East of the Meridian the line is nearly vertical, and West it is inclined about 30° to the horizontal; according to my practice the head would therefore be turned in the latter case so as to make the line joining the eyes parallel to that of the stars, whereas in the former case these lines would be at right angles. It cannot be denied that with the mode of observation employed the chances of a systematically different bisection of the bright image of *Sirius* by the fainter stars in these two positions are not inconsiderable, and it will be apparent from the parallax factors that such a difference would influence largely the parallax determination.

As far as the internal evidence of the series itself goes there does not seem to be much appearance of such error. There is apparently little or no break at the point where the observations change from the one side of the Meridian to the other, but the connecting link is weak, falling between January and February 1882, when there are but few observations. The solution of the equations, however, confirms this; assuming x to be different East and West of the Meridian, we have for the normals and their solutions—

All Observations.

$$\begin{array}{rrrrr} +28{\cdot}25x_w & +\ 0{\cdot}00x_E & +24{\cdot}87y & -10{\cdot}32z & =+1{\cdot}408^R \\ +\ 0{\cdot}00 & +23{\cdot}50 & -16{\cdot}02 & -\ 5{\cdot}18 & -1{\cdot}284 \\ +24{\cdot}87 & -16{\cdot}02 & +36{\cdot}86 & -\ 4{\cdot}10 & +2{\cdot}405 \\ -10{\cdot}32 & -\ 5{\cdot}18 & -\ 4{\cdot}10 & +10{\cdot}69 & -0{\cdot}130 \end{array} \qquad [p.nn] = 0{\cdot}2056$$

z	$=-0{\cdot}0006^R$	$\pm 0{\cdot}0083^R$	or with $z=$	0^R	
y	$+\ {\cdot}0720$	${\cdot}0099$	y	$+\ {\cdot}0718$	$\pm 0{\cdot}0094$
x_E	$-\ {\cdot}0056$	${\cdot}0075$	x_E	$-\ {\cdot}0056$	${\cdot}0075$
x_W	$-\ {\cdot}0137$	${\cdot}0108$	x_W	$-\ {\cdot}0134$	${\cdot}0090$
	$\pi = 0''{\cdot}510$	$\pm 0''{\cdot}070$		$\pi = 0''{\cdot}508$	$\pm 0''{\cdot}066$

Probable error, 1 obs. $\pm 0''{\cdot}245$ Probable error, 1 obs. $\pm 0''{\cdot}243$

Rejecting those Observations made with "Images 3."

$$\begin{array}{rrrrr} +26{\cdot}00x_w & +\ 0{\cdot}00x_E & +23{\cdot}35y & -9{\cdot}45z & =+1{\cdot}337^R \\ +\ 0{\cdot}00 & +23{\cdot}00 & -15{\cdot}69 & -5{\cdot}10 & -1{\cdot}202 \\ +23{\cdot}35 & -15{\cdot}69 & +35{\cdot}40 & -3{\cdot}70 & +2{\cdot}277 \\ -\ 9{\cdot}45 & -\ 5{\cdot}10 & -\ 3{\cdot}70 & +9{\cdot}99 & -0{\cdot}131 \end{array} \qquad [nn] = 0{\cdot}1850$$

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	R	R		R	R
z	$=-0\overset{s}{\cdot}0006$	$\pm 0\overset{s}{\cdot}0085$	or with z	$=0$	
y	$+\ \cdot0688$	$\cdot0103$	y	$+\ \cdot0686$	$\pm 0\overset{s}{\cdot}0098$
x_E	$-\ \cdot0055$	$\cdot0078$	x_E	$-\ \cdot0054$	$\cdot0078$
x_W	$-\ \cdot0106$	$\cdot0111$	x_W	$-\ \cdot0103$	$\cdot0095$

$\pi = 0''\cdot488 \pm 0''\cdot072$ $\pi = 0''\cdot486 \pm 0''\cdot072$

Probable error, 1 obs. $\pm$ 0·246 Probable error, 1 obs. $\pm$ 0·244

Of course the weight of the parallax is so small that it can hardly be considered as a numerical determination of any value, and may only serve to show how far the observations themselves betray any systematic error. The difference East—West comes out—

R	R	
$+0\overset{s}{\cdot}0051$	$\pm 0\overset{s}{\cdot}0136$,	all observations
$+0\overset{s}{\cdot}0049$	$0\overset{s}{\cdot}0123$,	rejecting "Images 3"

and the parallax is sensibly the same as before.

Notwithstanding this favourable result, there remained the possibility of a systematic error such as I have described having unduly affected the series, and I determined to test the point by the best means at my disposal, viz., as complete elimination as possible of the source of such error. It was not possible to attempt a new and complete determination of the parallax without prolonging my stay at the Cape and encroaching upon other work ; but it was possible to secure a number of observations at the two maxima of parallax in September 1882 and March 1883, which should be at least free from the defect of the former series. I therefore constructed a screen through which the image of *Sirius* appeared a trifle fainter than the comparison star *a* and a trifle brighter than *b*. With this arrangement it seemed in the highest degree probable that as long as the stars were well seen, any error of placing the fainter star constantly to the one side or the other of the brighter star would be completely eliminated in the difference *Sirius-b* − *Sirius-a*. I decided not without some regret however, not to make use of the reversing prism employed by GILL at Ascension to eliminate errors dependent upon the inclination of the line joining the stars to the horizon. The considerable loss of light occasioned by it seemed to me to render the measures of stars as faint as these under consideration so much more difficult as to counterbalance the advantages which might accrue from its use. These observations are those

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already referred to as Series II. Of course, from observations extending over only six months, the proper motion term cannot be determined, and must be eliminated by means of the former series.

I give first, for reasons which I will immediately explain, the solution of the equations Nos. 61 to 69 and 77 to 86, the two groups near the two parallax maxima. These give, with a uniform weight—

$$\begin{array}{l} +19{\cdot}00x + 1{\cdot}04y = {}^{R}+0{\cdot}008 + 0{\cdot}40z \\ +\ 1{\cdot}04 + 18{\cdot}06 \quad +1{\cdot}010 - 4{\cdot}47 \end{array} \quad [nn]=0{\cdot}0618$$

$$\begin{array}{lll} y = & {}^{R}+0{\cdot}0561 & -0{\cdot}250z \pm {}^{R}0{\cdot}0028 \\ x = & -\ {\cdot}0029 & +\ {\cdot}021 \qquad {\cdot}0027 \end{array}$$

$$\pi = {}''0{\cdot}397 - {\cdot}137z \pm {}''0{\cdot}020$$

Probable error, 1 obs. $\pm$ 0·156

The effect of z may be eliminated either by taking its value from Series I.—say from the last and probably best solution—

$$z = {}^{R}+0{\cdot}0007 \pm {}^{R}0{\cdot}0080$$

or by comparing the two values of x from the two series—

Series I. ...	...	1881·70	$x = -0{\cdot}0078 \pm 0{\cdot}0027$
„ II. ...	...	1882·98	$-\ {\cdot}0029 \qquad {\cdot}0027$
		1·28	$z = +0{\cdot}0049 \pm 0{\cdot}0038$
		z	$+\ {\cdot}0038 \qquad {\cdot}0030$

Introducing these values of z we have either—

$$\pi = {}''0{\cdot}396 \pm {}''0{\cdot}023 \text{ or}$$
$$\pi = 0{\cdot}392 \pm 0{\cdot}020$$

The residuals which the substitutions of $x = -0^{R}{\cdot}0029$, $y = +0^{R}{\cdot}0561$, and $z=0$ leaves are placed in Column I. They show that the atmospheric conditions have not exercised much influence on the accuracy of the observations, their probable error coming out:

Images 1–2, and 2,	2–3 and 3.	Steadiness 1–2 and 2,	2–3 and 3.
$\pm$ ″0·138	$\pm$ ″0·166	$\pm$ ″0·159	$\pm$ ″0·153.
8 obs.	11 obs.	7 obs.	12 obs.

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so that the above solution may stand as the final result of these observations.

My reason for not including the observations Nos. 70 to 76 is briefly that I do not consider them quite free from the suspicion of systematic error. They were made in bright twilight, as soon as the stars became visible; and, apart from the fact that the small difference of magnitude would on this account be exaggerated (more than during the other observations), the gradual darkening of the background may have introduced a source of error which by reason of the incompleteness of the observations—consisting, as they do, with but one exception, of only eight bisections—may not have been effectually eliminated. If they are taken into account, giving the "half sets" the weight $\frac{1}{2}$, the normals and their solution become—

$$\begin{array}{llll} +23{\cdot}00x + 4{\cdot}20y & = {}^{R}+0{\cdot}098 + 0{\cdot}05z & & [nn] = 0{\cdot}0667 \\ +\ 4{\cdot}20 \quad +20{\cdot}56 & \quad +1{\cdot}077 - 4{\cdot}75 & & \end{array}$$

$$\begin{array}{lll} & {}^{R} & {}^{R} \\ y = & +0{\cdot}0535 - 0{\cdot}240z & \pm\ 0{\cdot}0031 \\ x & \quad -0{\cdot}0053 + 0{\cdot}002z & \quad 0{\cdot}0029 \end{array}$$

$$\pi = 0''{\cdot}378 - {\cdot}132z \pm 0''{\cdot}022$$

Probable error, 1 obs. $\pm$ 0·177

The parallax is not sensibly altered by any plausible assumption for z, and is not materially different from that given by the first solution, which rejects these incomplete observations, and which is, in my opinion, the best.

Comparing these results with those from Series I. it is seen that the accuracy of the observations has been greatly increased by the use of the new screen; from the two values for the probable error of one night's work—

Series I.	...	...	...	$\pm\ 0''{\cdot}241$
„ II.	...	...	...	0·156

we may infer that the variations in the mode of bisecting the brighter star from night to night have introduced an additional casual error of

$$\pm\ 0''{\cdot}184.$$

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As to the question of systematic error; the two values of the parallax from the two series are

$$\text{Series I. } \pi = 0''\cdot467 \pm 0''\cdot022$$
$$\text{,, II. } \pi = 0\cdot392 \quad 0\cdot020$$

These values certainly differ more than their probable errors warrant, and it would seem, therefore, that Series I. has suffered from systematic error.

If this be the case the estimate of its probable error from the agreement of the observations, assuming their freedom from systematic error, is illusory, and must be replaced by the value—

$$\pm 0''\cdot072$$

which results from the solution where such error is taken into consideration. I have, however, considered it advisable to increase the low relative weight of Series I., which this figure would imply, to the value $\frac{1}{4}$, and find thus—

$$\pi = 0''\cdot407 \pm ''\cdot018,$$

which may be taken as the final result of this paper.

It seems hardly worth while to solve the equations, assuming the freedom of Series I. from systematic error ; but as I have the results of such a solution before me, I may state that if the normals from Series I. are given the weight $\frac{1}{2}$ instead of their theoretical weight, $0\cdot42=(0\cdot156)^2\ (0\cdot241)^2$, and only make use of those which take observations with "Images 1 to 2–3," the values are formed—

	R	R
$z=$	$-0\cdot0025$	$\pm 0\cdot0027$
y	$+\ \cdot0607$	$\cdot0022$
x	$-\ \cdot0057$	$\cdot0021$

$$\pi = 0''\cdot429 \pm 0''\cdot015$$

Probable error, 1 obs. of weight 1 $\pm 0\cdot167$

The residuals for this solution are found in Column II., those in brackets being the ones corresponding to the observations not made use of ; from them may be judged to what extent violence is done in combining both series into one.

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§ 7. *Parallax of* ϵ *Indi.* GILL.

To investigate the parallax of ϵ *Indi*, I have measured its distance from the comparison stars α and β mentioned in the Introduction.

The screen employed consists of a simple fold of dense wire gauze, which, placed over the segment of the object-glass through which ϵ *Indi* is viewed, reduces the image of that star to similar brightness with that of its comparison star β. It would have been advantageous to employ a screen not quite so dense, so that the image of ϵ *Indi* might have appeared a little brighter than the comparison star β, and a little fainter than α in the field of view, but I had no suitable gauze.

The series of observations is not quite so complete as might be wished. There are in all 58 observations, begun in July 1881, but not continued with regularity till after the end of August of the same year. The observations are then pretty regularly continued till the beginning of September 1882, when the observations of *Victoria* and *Sappho*, and of the great Comet of that year, compelled me to stop, though not, as I then thought, until a sufficient number of observations had been secured. The series is indeed sufficient to give a good determination of the parallax of ϵ *Indi*, if we assume that the observations are free from systematic error of observation depending on the hour angle. But from the fact that, with two exceptions, the first half of the series is made West of the Meridian, and with three exceptions, the second half is made East of the Meridian, the proper motion and parallax cannot be determined from the observations with much weight, if the observations are considered liable to such suspicion. I have formed the equations however (p. 123), writing x_W for the correction of the adopted mean difference of the distances for observation West, and x_E for observations East of the Meridian. A glance at the equations will thus enable the reader to judge of the validity of the above remarks.

At Ascension in 1877, I measured the distance of ϵ *Indi* from the same stars of comparison on two nights ; but on account of the large proper motion of the star, different divisions of the scale were employed in these observations. To have employed at the Cape the same scale divisions as those observed

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at Ascension would have introduced an undesirable amount of reliance on the accurate determination of the run of the micrometer screw. Besides this, when the Heliometer arrived at the Cape, the scales were found to be coated with a strongly adhering fungus, which had to be removed by polishing with fine oxide of iron powder applied with the finger. After such a process, I am by no means certain that the old determinations of division error can be relied upon within the necessary limits of accuracy, nor were the conditions of $p-q$ at Ascension (or, rather, the inclination of the line joining the stars to that of the line joining the observer's eyes) similar with those at the Cape. For these reasons I have thought it undesirable to introduce the Ascension observations into the present discussion, preferring to treat the observations of the present series as if free from the systematic errors in question, but leaving the equations in such a form that the results of additional observations could be readily applied to them.

For the proper motion of ϵ *Indi* I have adopted the results of the following discussion by ELKIN, adding to it only the results of recent Cape Meridian observations.

The material for determining the proper motion of ϵ *Indi* is scant. In R.A. the earliest accurate places are those in the Cape Catalogue for 1840. Bringing up 26 stars between $20^h\ 50^m$ and $22^h\ 50^m$, and from N.P.D. 140° to 155° to 1880, the mean correction to reduce the 1840 places to STONE is found $= +0^s{\cdot}03$. TAYLOR'S epoch is probably about 1839·2 for the three observations in Vol. V. of "Madras Observations;" and as there are six observations given in the *General Catalogue*, probably the three others were made about 1843·2—as may be inferred from the preliminary remarks, pp. 1 and 2, to the *General Catalogue*. He assumes $+0^s{\cdot}400$ for the proper motion in R.A.

In Vol. VII. of the "Madras Observations" a further place is given for which the epoch may be assumed 1845·7. The *General Catalogue* place requires, according to DE BALL,* a correction of $-0^s{\cdot}17$ to reduce to the Cape Catalogue 1860, and it is stated in Vol. VII. of the "Madras Observations" that the places there given are $0^s{\cdot}10$ less than those in the *General Catalogue*.

The epochs are of course given for the modern places. The Melbourne

* De Ball: Ueber die eigene Bewegung des Sonnensystems.

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place requires a correction of $-0^s.11$ to reduce it to the Cape Catalogue 1860, according to DE BALL, and the Cordoba places seem to need a correction of $+0^s.04$ to reduce to STONE. Assuming the identity of the Cape Catalogue 1860 and STONE, and reducing all to STONE, there results with the proper motion $+0^s.480$:

Mean R.A. 1880·0.

		h m s		
Cape, 1840	1836·74	21 54 10·07	4	observations.
Taylor, Gen. Cat. ...	41·2	10·22	6	„
„ vol. vii. ...	45·7	10·14	2	„
Melbourne	63·8	10·04	6	„
Cape, 1880	75·70	10·08	3	„
Cordoba*	76·5	10·11	21	„
Cape Obs.	83·72	10·075	12	„

In Declination, BRISBANE'S epoch may be roughly guessed at as 1824·0. TAYLOR'S epochs are the same as above for R.A., and he uses $-2''.9$ for the proper motion. DE BALL gives, to reduce TAYLOR and Melbourne to Cape 1860, $0''.0$ and $-0''.7$ respectively. DOWNING finds the reduction for Melbourne to Cape 1880 (STONE) $-0''.6$.

The Cordoba places appear to require a correction of $-1''.5$ to reduce them to STONE. Assuming TAYLOR and the Cape Catalogues as identical, and reducing all to them, we have with the proper motion $-2''.60$:

Mean Declination, 1880.

		° ′ ″		
Brisbane	1824·0	−57 16 35·62	2	observations.
Taylor, Gen. Cat. ...	41·2	39·3	6	„
„ vol. vii. ...	45·7	41·3	2	„
Melbourne	63·8	39·2	6	„
Cape, 1880	75·70	39·6	3	„
Cordoba *	76·5	39·9	21	„
Cape Obs.	83·72	39·4	12	„

The assumed proper motions appear to require no sensible corrections but are evidently uncertain, in R.A. perhaps only $0^s.003$, in Declination $0''.05$ or more.

* Communicated by Dr. GOULD.

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The following are the existing Meridian observations of the Stars of Comparison, reduced without proper motion to the Equinox 1882·0 :—

Equinox 1882·0.

			α			β	
			h m s			° ′ ″	
Cordoba	... ...	1877·9	21 49 56·32	12	−57	15 55·8	12
Cape Merid. Obs.	...	1883·84	21 49 56·38	4		15 56·0	6
			β				
			h m s			° ′ ″	
Cordoba Zone 421	...		21 59 38·33	1	−57	25 26·4	1
Cape Merid. Obs.	...	1883·72	21 59 38·30	12		25 28·5	12

The observations have been reduced with the following values of p and s, derived from the Heliometer observations before the Meridian observations were made.

1882·0

	p	s
	°	R
Star α	270·35	165·8
Star β	102·17	205·2

The proper motion of ϵ *Indi*, from ELKIN's data, above quoted, is equivalent to—

$$4''\cdot681 \text{ in the direction } p = 123^\circ\cdot74$$

which, projected on the lines ϵ *Indi*-α and ϵ *Indi*-β, corresponds with the following annual variations of these distances in terms of the screw, viz.—

$$\text{Distance } \alpha = +0\cdot3038 \text{ R}$$
$$\text{,, } \beta = -0\cdot3384$$

The parallax factors are

For distance from α 0·9390 R cos ($\odot$ − 56°·60)
,, ,, β 0·8808 R cos ($\odot$ −246°·00)

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Thence for

$$\beta - \alpha \text{ the factor is } 1{\cdot}814 \text{ R cos } (\odot - 241^{\circ}{\cdot}15),$$

and for

$$\beta + \alpha \quad \text{,,} \quad 0{\cdot}160 \text{ R cos } (\odot - 172^{\circ}{\cdot}57).$$

The following Table exhibits the results of the separate observations, reduced on the same plan as my preceding observations of *α Centauri* and *Sirius*.

The sums of the distances have been corrected for an assumed approximate parallax $=0^{R}{\cdot}02$,—that is, by application of a correction,

$$-0{\cdot}0032 \text{ R cos } (\odot - 172^{\circ}{\cdot}6).$$

The corrections for aberration are

$$aA + bB,$$

where

	For Star α.	For Star β.
Log. a =	$-6{\cdot}7191$	$= -6{\cdot}8056$
b	$-6{\cdot}5666$	$-6{\cdot}6642$

The mean of the sums of the distances so corrected (S_0) is $371^{R}{\cdot}0767$, and the adopted mean difference of the distances (D_0) is $39^{R}{\cdot}4500$, whence the correction of $\beta - \alpha$ to normal scale value is

$$\Delta D = \frac{D_o}{S_o} (S_o - S) = 0{\cdot}106 (S_o - S).$$

Observations.

No.	1881	h m	I.	S.	Ther.	α	β	β−α+ΔD
						R	R	R
1	July 8	20 6	1-2	1-2	48·0	165·8663	205·2913	39·4166
2	Aug. 31	2 32	2-3	2	52·2	·7960	·2654	·4714
3	Sept. 3	22 54	2	2	49·3	·8142	·2534	·4405
4	6	3 10	3-4	3	42·2	·7887	·2806	[·4930]
5	7	22 50	2	2	53·3	·8093	·2517	·4444
6*	10	23 7	2	2	53·3	·8166	·2514	·4361
7	13	23 19	1	2	45·2	·7835	·2594	·4798
8	20	21 1	1-2	2	56 0	·8094	·2414	·4351
9	21	23 52	2-3	3	58·0	·8119	·2637	·4523

* Stars faint by haze

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Observations—continued.

No.			I.	S.	Ther.	α	β	β−α+ΔD
	1881	h m				R	R	R
10	Sept. 24	0 39	2–3	2–3	56·7	165·8234	205·3009	39·4728
11	Oct. 10	0 55	1	1	49·7	·8003	·2687	·4695
12	12	0 4	1–2	1–2	57·2	·8123	·2762	·4630
13	13	1 47	2–3	2–3	64·7	·7981	·2810	·4829
14	28	0 38	1	1	49·2	·8106	·2779	·4663*
15	31	0 30	2–3	2–3	51·7	·7934	·2711	·4792
16	Nov. 10	0 9	2	2	51·3	·8113	·2933	·4792*
17	14	1 12	2–3	2–3	54·7	·7877	·2748	·4888
18	20	1 2	3	3	59·0	·7736	·2596	·4907
19	24	1 31	3	3	58·3	·7912	·2857	·4946
20	Dec. 1	2 13	1–2	2–3	53·8	·8243	·3106	·4802
21	18	2 34	3	3	59·0	·8099	·2776	·4665 ½ set
22	24	3 9	2–3	2–3	64·5	·8103	·2534	·4444
23	25	3 19	1–2	2–3	59·0	·8031	·2669	·4644
24	27	3 31	2	2–3	63·7	·7835	·2560	·4764
	1882							
25	Jan. 8	4 3	—	—	61·8	·7927	·2635	·4728
26	11	4 25	2	2–3	63·3	·8106	·2659	·4552
27	March 9	15 30	3-4	3-4	61·5	·8074	·2372	[·4329]
28	12	15 43	3	3	63·8	·8318	·2352†	[·4041]
29	13	15 34	2	2–3	59·0	·8328	·2416	·4087
30	20	16 23	2	2–3	62·3	·8217	·2574	·4351
31	23	16 37	2–3	2–3	57·3	·8296	·2500	·4198
32	30	16 44	1–2	1–2	54·8	·8187	·2467	·4289 ½ set
33	31	17 6	1–2	2	63·1	·8402	·2612	·4181
34	April 7	16 56	2–3	3	62·0	·8319	·2400	·4083
35	9	17 16	1–2	1–2	61·5	·8251	·2414	·4171
36	12	18 4	2	2–3	60·0	·8284	·2305	·4037
37	13	17 9	1–2	2	58·9	·8286	·2283	·4015
38	18	16 47	2–3	2–3	60·8	·8281	·2306	·4041
39	May 6	19 21	2	2	51·3	·8251	·2096	·3888
40	23	17 16	1–2	2	56·0	·8200	·2232	·4066
41	24	17 6	2	2	56·3	·8071	·2311	·4280
42	June 20	17 40	1–2	1–2	47·0	·8832	·2896	·3963 ½ set
43	24	18 36	2–3	2–3	55·0	·8870	·2832	·3864
44	July 1	18 18	1–2	1–2	45·0	·8330	·2317	·3973
45	9	18 43	1–2	1–2	47·5	·8148	·2420	·4295
46	10	18 33	—	—	41·0	·8322	·2402	·4086

* Stars faint by haze.

† Focal length afterwards found displaced to read 9·90; the focal reading was presumably correct (9·50) at the beginning of the series.

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Observations—continued.

No.			I.	S.	Ther.	α	β	$\beta-\alpha+\Delta D$
	1882	h m				R	R	R
47	July 26	16 58	3	3	52·3	165·8437	205·2384	39·3944
48	Aug. 11	2 45	—	—	53·5	·8212	·2375	·4185 ½ set
49	16	2 49	3	3	49·5	·8251	·2624	·4365
50	17	18 12	3	3	58·0	·8352	·2503	·4145
51	22	18 28	—	—	58·1	·8020	·2670	·4661
52	24	18 4	1	1–2	55·0	·8339	·2809	·4433 ½ set
53	26	18 37	—	—	55·0	·8252	·2623	·4363
54	31	18 33	2	2	52·0	·8331	·2708	·4351
55	Sept. 12	18 22	—	—	57·0	·8092	·2543	[·4468] ¼ set
56	22	19 24	—	—	56·3	·7982	·2800	·4820 ½ set
57	Nov. 9	1 38	1	1	55·0	·8150	·2848	·4675 ½ set
58	18	2 0	3–4	3–4	59·0	·8489	·2828	[·4282] ½ set

Assuming the mean value of $\beta-\alpha$ for 1882·0 to be $39^{R}\cdot450$, we obtain the following equations of condition, in which

x_E and x_W have the already explained meanings,

y is the error of the assumed annual variation of $\beta-\alpha$,

$$\text{and } \pi = \frac{z}{1\cdot814}.$$

The Columns marked I. II. and III. contain the representations of different solutions of the equations more fully described afterwards. The column marked p, adjacent to Column I., indicates the weights applied in Solution I. The Column p, between Columns II. and III., indicates the weights applied in Solutions II. and III.; where no figure appears in Column p the weight is understood to be *unity*.

Equations of Condition. Series I.

No.					I.		II.		III.
					v	p	v	p	v
				R					
1	x_E	$-0\cdot484y$	$-0\cdot709z$	$=-0\cdot033$	+·001		+·006		+·006
2	x_W	−·336	+·137	+·021	+ 24		+ 22		+ 26
3	x_W	−·328	+·183	−·010	− 9		[− 10]		[− 13]
4	x_W	−·319	+·236	[+·043]			[+ 41]		[+ 44]
5	x_W	−·318	+·250	−·006	− 8		[− 9]		[− 6]
6	x_W	−·309	+·298	−·0 4	− 18		[− 19]		[− 16]

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Equations of Condition. Series I.—continued.

No.					I.		II.		III.
					v	p	v	p	v
				R					
7	x_W	$-0\cdot300y$	$+0\cdot346z$	$=+0\cdot030$	$+\cdot025$		[$+\cdot024$]		[$+\cdot026$]
8	x_E	$-\cdot282$	$+\cdot456$	$-\cdot015$	-24		[-19]		[-23]
9	x_W	$-\cdot279$	$+\cdot472$	$+\cdot002$	-8		-9		-7
10	x_W	$-\cdot270$	$+\cdot515$	$+\cdot023$	$+11$		$+11$		$+12$
11	x_W	$-\cdot227$	$+\cdot725$	$+\cdot020$	$+1$		0		$+1$
12	x_W	$-\cdot221$	$+\cdot749$	$+\cdot013$	-7		-8		-7
13	x_W	$-\cdot218$	$+\cdot760$	$+\cdot033$	$+12$		$+11$		$+13$
14	x_W	$-\cdot178$	$+\cdot896$	$+\cdot016$	-10		-10		-10
15	x_W	$-\cdot169$	$+\cdot918$	$+\cdot029$	$+2$		$+2$		$+2$
16	x_W	$-\cdot142$	$+\cdot966$	$+\cdot029$	$+1$		0		0
17	x_W	$-\cdot131$	$+\cdot978$	$+\cdot039$	$+10$		$+10$		$+10$
18	x_W	$-\cdot115$	$+\cdot987$	$+\cdot041$	$+12$		$+11$	$\frac{1}{2}$	$+12$
19	x_W	$-\cdot104$	$+\cdot986$	$+\cdot045$	$+16$		$+15$	$\frac{1}{2}$	$+16$
20	x_W	$-\cdot084$	$+\cdot974$	$+\cdot030$	$+2$		$+1$		$+1$
21	x_W	$-\cdot038$	$+\cdot891$	$+\cdot017$	-8	$\frac{1}{3}$	-9	$\frac{1}{4}$	-9
22	x_W	$-\cdot022$	$+\cdot833$	$-\cdot006$	-28		-30		-29
23	x_W	$-\cdot019$	$+\cdot823$	$+\cdot014$	-8		-10		-9
24	x_W	$-\cdot013$	$+\cdot804$	$+\cdot026$	$+5$		$+3$		$+4$
25	x_W	$+\cdot020$	$+\cdot665$	$+\cdot023$	$+7$		$+5$		$+7$
26	x_W	$+\cdot028$	$+\cdot626$	$+\cdot005$	-9		-11		-10
27	x_E	$+\cdot185$	$-\cdot313$	[$-\cdot017$]			[$+7$]		[$+6$]
28	x_E	$+\cdot194$	$-\cdot362$	[$-\cdot046$]			[-20]		[-21]
29	x_E	$+\cdot196$	$-\cdot378$	$-\cdot041$	-15		-14		-15
30	x_E	$+\cdot216$	$-\cdot488$	$-\cdot015$	$+15$		$+16$		$+15$
31	x_E	$+\cdot224$	$-\cdot534$	$-\cdot030$	$+6$		$+2$		$+2$
32	x_E	$+\cdot243$	$-\cdot632$	$-\cdot021$	$+15$	$\frac{1}{2}$	$+15$	$\frac{1}{2}$	$+15$
33	x_E	$+\cdot246$	$-\cdot646$	$-\cdot032$	$+4$		$+5$		$+4$
34	x_E	$+\cdot265$	$-\cdot734$	$-\cdot042$	-2		-2		-2
35	x_E	$+\cdot270$	$-\cdot757$	$-\cdot033$	$+7$		$+8$		$+8$
36	x_E	$+\cdot278$	$-\cdot791$	$-\cdot046$	-4		-4		-4
37	x_E	$+\cdot281$	$-\cdot801$	$-\cdot049$	-7		-7		-6
38	x_E	$+\cdot295$	$-\cdot851$	$-\cdot046$	-2		-2		-1
39	x_E	$+\cdot342$	$-\cdot967$	$-\cdot061$	-12		-12		-11
40	x_E	$+\cdot390$	$-1\cdot013$	$-\cdot043$	$+8$		$+7$		$+8$
41	x_E	$+\cdot393$	$-1\cdot012$	$-\cdot022$	$+29$		$+28$		$+29$
42	x_E	$+\cdot467$	$-\cdot895$	$-\cdot054$	-7	$\frac{1}{2}$	-8	$\frac{1}{2}$	-7
43	x_E	$+\cdot478$	$-\cdot861$	$-\cdot064$	-18		-20		-19
44	x_E	$+\cdot497$	$-\cdot792$	$-\cdot053$	-10		-11		-11

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Equations of Condition. Series I.—continued.

No.				R	I.		II.		III.
					v	p	v	p	v
45	x_E	$+0\cdot519y$	$-0\cdot700z$	$=-0\cdot021$	$+\cdot019$		$+\cdot018$		$+\cdot018$
46	x_E	$+\cdot522$	$-\cdot689$	$-\cdot041$	-2		-3		-3
47	x_E	$+\cdot565$	$-\cdot468$	$-\cdot056$	-25		-26	$\frac{1}{2}$	-26
48	x_W	$+\cdot610$	$-\cdot208$	$-\cdot032$	-7	$\frac{1}{2}$	-18	$\frac{1}{2}$	-13
49	x_W	$+\cdot623$	$-\cdot123$	$-\cdot014$	$+4$		-3	$\frac{1}{2}$	$+2$
50	x_E	$+\cdot625$	$-\cdot114$	$-\cdot036$	-18		-19	$\frac{1}{2}$	-21
51	x_E	$+\cdot639$	$-\cdot029$	$+\cdot016$	$+31$		$[+30]$		$[+28]$
52	x_E	$+\cdot644$	$+\cdot006$	$-\cdot007$	$+6$	$\frac{1}{2}$	$+6$	$\frac{1}{2}$	$+4$
53	x_E	$+\cdot650$	$+\cdot040$	$-\cdot014$	-2		-2		-5
54	x_E	$+\cdot663$	$+\cdot126$	$-\cdot015$	-6		-7		-9
55	x_E	$+\cdot696$	$+\cdot325$	$[-\cdot003]$			$[-2]$		$[-5]$
56	x_E	$+\cdot724$	$+\cdot481$	$+\cdot032$	$+27$	$\frac{1}{2}$	$+27$	$\frac{1}{2}$	$+23$
57	x_W	$+\cdot855$	$+\cdot962$	$+\cdot018$	-4	$\frac{1}{2}$	-10		-10
58	x_W	$+\cdot880$	$+\cdot985$	$[-\cdot022]$			$[-53]$		$[-51]$

In forming the normals, equations 4, 27, and 58 are rejected because they depend on observations made in circumstances of definition less favourable than are indicated by the figure 3.

The equation 28 is rejected for reasons given in the foot-note attached to the corresponding observation.

Equation 55 is also rejected because it depends on a "quarter set" of observations, the observation is therefore unsymmetrical.

Equations 21, 32, 42, 48, 52, 56 and 57 have received $\frac{1}{2}$ weight because they depend on "*half sets*" of observations.

If for reasons already stated we now write

$$x = x_W = x_E$$

the resulting normals are

$$\begin{aligned} 49\cdot50x + 6\cdot43y + 2\cdot35z &= -0\cdot426 \\ 6\cdot43 + 6\cdot80 - 6\cdot13 &\quad -\cdot338 \\ 2\cdot35 - 6\cdot13 + 23\cdot85 &\quad +\cdot934 \end{aligned}$$

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The solution of these normals and the substitution of the values of the unknowns in the original equations leads to the following results :—

$$[p.vv] = 0''.01086 \qquad \epsilon^2 = 0''.000217$$

x	$= -0''.0097$,	Weight 39·80,	Probable error $\pm 0''.0016$
y	$- \cdot 0057$,	„ 4·22,	„ „ ·0048
z	$+ \cdot 0386$,	„ 16·80,	„ „ ·0024

and the probable error of one observation—

$$\pm 0''.00994 = \pm 0''.125$$

$$\pi = 0''.274 \pm 0''.017$$

The representation of this solution is given in the column marked I., adjacent to the Equations of Condition.

Before completing my observing work in 1883, I was able to secure the following small number of additional observations :—

Observations of ε Indi. Series II.

No.			I.	S.		α	β	β − α + ΔD
	1883.	h m			°	R	R	R
59	Oct. 21	1 15	2–3	3	54·5	165·8013	205·2869	39·4847
60	22	1 16	2	2–3	54·0	·8025	·2780	·4754
61	28	1 16	3	3	62·3	·7901	·3083	·5162 ½ set
62	29	1 42	2–3	2–3	66·5	·8146	·2779	·4619
63	Nov. 6	2 9	1–2	2	54·0	·7913	·2726	·4829

These observations treated in like manner with those of the first series lead to the following equations :—

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Equations of Condition. Series II.

No.		I.		II.		III.
				v	p	v
59	x_W +1·804y +0·836z = +0·035			+ ·011		+ ·012
60	x_W +1·806 + ·845 + ·025			+ 1		+ 2
61	x_W +1·822 + ·893 + ·066			+ 40	¼	+ 41
62	x_W +1·825 + ·900 + ·012			− 14		− 13
63	x_W +1·847 + ·948 + ·033			+ 5		+ 6

In forming normals from the equations, in combination with the first series, it is desirable to consider the possible effect of systematic error in the observations.

The following Table gives the value of $p-q$ for each hour angle of observation, p being taken equal to the mean of the position angles, or rather

$$= \frac{p_\alpha + (p_\beta + 180°)}{2} = 276°·3$$

Where p_α and p_β are the position angles of the stars α and β with respect to ϵ *Indi*.

West. Hour Angle.		East. Hour Angle.	
	$p-q$.		$p-q$.
h	°	h	°
α+1	246·3	α−1	306·3
+2	222·4	−2	330·2
+3	204·4	−3	348·2
+4	190·1	−4	362·6
+5	177·7	−5	14·9
+6	166·3	−6	26·3
+7	155·3	−7	37·4

Thus East of the Meridian the direction of measurement is more nearly vertical than horizontal at all hour angles except those less than 2^h from the Meridian, and practically the same is true for Western hour angles. A glance at the observations will show that most of them have been made earlier than

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$19^h\ 50^m$ and later than $23^h\ 50^m$, and consequently that, with few exceptions, the whole of the observations have been made with the head so turned that the stars, by motion in position angle, cross through each other in a direction parallel to the line joining the observer's eyes.

We have therefore chiefly to consider whether a difference of 180° in the value of $p-q$ produces any systematic difference in the habit of observation; that is, whether, in observing, I caused the fainter star to cross above or below the centre of the image of the brighter star. By rejecting a very few observations, the problem is thus reduced to the very simple one of considering x_E different from x_W.

Therefore, in forming normals from the combined series, the following equations have been rejected, because they depend upon observations made exceptionally near the Meridian, *i.e.* when the stars are more nearly horizontal than vertical, viz.—3, 5, 6, 7, 8.

Equations 4, 27, 28, 55, and 58 are rejected for the same reasons as in the former solution.

Equations 32, 42, 48, 56, and 57 have received half weight because they depend on half sets of observations; and, in order to make the solution final, half weight has also been assigned to the following complete equations made with "Images 3," viz.—18, 19, 47, 49.

Equations 21, 61, depending on half sets of observations made with "Images 3," have received $\frac{1}{4}$ weight.

Equation 51, for which the state of definition is not described, and which gives an abnormal residual in the first solution, has also been rejected.

The resulting normals are

$+22{\cdot}00x_E$		$+\ 7{\cdot}88y$	$-13{\cdot}38z$	$=-0{\cdot}772$
	$+23{\cdot}00x_W$	$+\ 6{\cdot}40$	$+17{\cdot}12$	$+\ {\cdot}472$
$+\ 7{\cdot}88$	$+\ 6{\cdot}40$	$+19{\cdot}45$	$+\ 1{\cdot}50$	$-\ {\cdot}095$
$-13{\cdot}38$	$+17{\cdot}12$	$+\ 1{\cdot}50$	$+25{\cdot}37$	$+\ {\cdot}984$

Their solution, and the substitution of the values of the unknowns lead to the following results :—

$$[p.vv] = 0{\cdot}006986, \qquad \varepsilon^2 = 0{\cdot}0001455.$$

x_E	$=-0{\cdot}0128$,	Weight	6·64,	Probable error	$\pm\ 0{\cdot}0032$
x_W	$-\ {\cdot}0065$	,,	5·97	,,	·0033
y	$-\ {\cdot}0003$	,,	14·33	,,	·0021
z	$+\ {\cdot}0366$	,,	4·32	,,	·0039

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The probable error of one observation is

$$\pm\overset{R}{0}\cdot00814 = \pm\overset{''}{0}\cdot1047,$$

and

$$\pi = \overset{''}{0}\cdot260 \pm \overset{''}{0}\cdot028.$$

The representation of this solution is given in column marked II., adjacent to the equations.

The difference $x_W - x_E$ is $+0^R\cdot0063$, with a *mean error* of $\pm0\cdot0068$. There is thus no evidence of a systematic error depending on the hour angle of observation, that found being less than its mean error.

If, therefore, we suppose that the difference $x_W - x_E$ is not real but accidental, we can write $x = x_W = x_E$ in the above normals. We then obtain :

$$[p.vv] = \overset{R}{0}\cdot007111, \qquad \epsilon^2 = \overset{R}{0}\cdot0001451$$

$x =$	$-\overset{R}{0}\cdot0104,$	Weight	32·2,	Probable error	$\pm\overset{R}{0}\cdot0014$
y	$-$ ·0040	„	14·7	„	·0021
z	$+$ ·0403	„	25·0	„	·0016

The probable error of one observation is

$$\pm\overset{R}{0}\cdot00812 = \pm\overset{''}{0}\cdot1045$$

and

$$\pi = \overset{''}{0}\cdot286 \pm \overset{''}{0}\cdot0115.$$

The representation of this solution is given in Column III., adjacent to the equations.

The introduction of the additional term (*i.e.* separating x into x_W and x_E) has thus slightly increased the probable error of one observation; and having regard to this fact, and like experience in the case of *Lac.* 9352, &c., it appears quite unnecessary to adopt other variations of weight or changes of solution.

No legitimate discussion can yield a result from those observations

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materially differing from 0″·27, and the probable error may also be fixed at ±0″·02 as an outside limit.

I therefore accept as the definite result of this investigation

$$\pi = 0''\cdot27 \pm 0''\cdot02.$$

§ 8. *Parallax of* ε *Indi.* Elkin.

The ε *Indi* series was the third which we proposed to observe continuously throughout the year, and for which there would be two independent results from the two observers. As regards the continuity of the series, it will be seen that this has been slightly impaired in May and June 1881, and January 1882, for the same reasons stated with reference to the *Sirius* observations; in February 1882, the only month in which there are no observations, ε *Indi* is in conjunction with the Sun, and not to be observed at sufficient altitudes.

The pair of comparison stars selected were very advantageously situated for parallax factor, and fairly symmetrically placed with respect to ε *Indi*. The approximate positions are—

Star.	Magnitude.	Distance.	Position Angle.
		R	° ′
a	7½	406·4	244 50
b	7¾	459·5	63 6
	Difference ...	53·1	181 44

and the factor of parallax for the *difference* of the two distances is—

$$+2\cdot000\ \mathrm{R}\ \sin(\odot + 231^\circ\cdot6),$$

and that for their *sum*—

$$+0\cdot020\ \mathrm{R}\ \sin(\odot + 321^\circ\cdot3).$$

In the Table which follows the observations are given in the same way

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as for the other stars ; the distances are corrected for aberration, this correction amounting to—

$$\begin{aligned} &+0^{R}\cdot0303 \sin (\odot + 53^{\circ}\cdot1) \text{ for } \epsilon \textit{ Indi-a} \\ &+0^{R}\cdot0343 \sin (\odot + 51^{\circ}\cdot0) \text{ ,, } \epsilon \textit{ Indi-b}, \end{aligned}$$

and they are reduced to 1882·0, assuming the annual proper motion of ϵ *Indi* $+0^{s}\cdot480$ in R.A. and $-2''\cdot60$ in Declination, which gives the annual motions—

$$\begin{aligned} \text{For } \epsilon \textit{ Indi-a} \quad & +0^{R}\cdot1878 \\ \epsilon \textit{ Indi-b} \quad & -0^{R}\cdot1783, \end{aligned}$$

the second term being insensible for the period in question. There are no early reliable observations of the comparison stars, they not being among those observed by GILL at Ascension in 1877.

Observations.

No.	Date.	Sid. Time.	Images.	Stead.	Temp.	ϵ Indi-*a*.	ϵ Indi-*b*.
	1881	h m			°	R	R
1	April 4	18 10	2	2–3	59·4	406·431	459·545
2	9	18 27	2	2	58·5	·341	·450
3	12	17 12	2	3–4	57·0	·366	·491
4	20	17 30	2	3	52·9	·469	·594
5	22	17 46	2–3	3	57·9	·446	·572
6	24	18 30	2	2	58·7	·471	·563
7	28	19 41	2	2–3	44·8	·441	·526
8	May 6	19 15	2–3	3–4	51·9	·490	·556
9	9	19 16	2	2	44·6	·420	·513
10	June 21	17 50	2	2–3	57·8	·440	·543
11	July 2	17 22	3	3	40·9	·478	·585
12	3	16 3	2–3	3–4	51·2	·451	·588
13	5	18 20	2–3	3	45·4	·446	·589
14	10	17 56	2	2–3	47·9	·415	·555
15	11	18 22	2	2	49·3	·409	·557
16	Aug. 12	20 7	1–2	2	49·8	·369	·486
17	14	20 59	2	2	54·1	·369	·483

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Observations—continued.

No.	Date.	Sid. Time.	Images.	Stead.	Temp.	ε Indi-*a*.	ε Indi-*b*.
	1881	h m			°	R	R
18	Aug. 18	17 43	3	3	56·2	406·401	459·517
19	27	20 5	2	2	53·5	·386	·478
20	29	21 12	2	2	55·5	·377	·491
21	Sept. 5	0 35	2	2	46·2	·384	·486
22	8	20 10	3	3	66·6	·371	·486
23	19	20 24	3	3	56·7	·363	·512
24	23	21 20	2–3	2–3	59·0	·378	·496
25	Oct. 6	23 50	2	2	54·7	·406	·529
26	12	1 36	2–3	2–3	57·5	·384	·552
27	19	1 27	2–3	2–3	60·0	·370	·528
28	28	2 20	2	2	46·8	·301	500
29	31	1 59	2	2–3	50·5	·331	·467
30	Nov. 3	0 12	3	2–3	60·1	·374	·484
31	5	0 36	2	2–3	60·4	·347	·495
32	7	2 15	3	3	55·2	·379	·485
33	15	1 20	1	2	55·5	·367	·476
34	18	1 13	2	2	52·5	·363	·473
35	24	3 5	3	3–4	57·8	·363	·509
36	Dec. 11	2 3	2–3	2–3	62·0	·417	·560
37	16	2 18	3	3–4	60·0	·390	·544
38	17	3 4	2	2–3	60·0	·388	·555 ½ set
39	20	3 10	2–3	3	62·0	·382	·526
	1882.						
40	Jan. 4	3 36	2–3	3	66·0	·400	·486
41	20	4 17	2–3	3–4	63·0	·383	·499
42	March 10	16 4	3	3–4	55·0	·466	·513
43	April 2	16 18	2–3	2–3	62·0	·388	·513
44	8	17 9	1–2	2	52·5	·384	·494
45	17	19 26	2	2–3	60·0	·386	·440 ⅞ set
46	18	18 12	2–3	2–3	60·5	·386	·484
47	19	16 18	2	3–4	58·2	·395	·498
48	25	16 12	2	2–3	54·0	·401	·467 ¾ set
49	May 6	16 46	2	2–3	52·5	·357	·466
50	18	16 28	2	3–4	51·0	·375	·487

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The equations of condition are deduced similarly as for the previous stars. The mean value of the sum of the two distances is—

$$\overset{R}{865{\cdot}910}.$$

By inadvertence, however, instead of using this value, the differences have been corrected by the formula—

$$-(\text{Observed sum} - \overset{R}{865{\cdot}890})\,\frac{53{\cdot}1}{865{\cdot}9},$$

so that the resulting value of the mean difference must be increased by

$$\overset{R}{+0{\cdot}0012}.$$

The unknowns have the same signification as before, x denoting the correction to the assumed mean difference—

$$\overset{R}{53{\cdot}120},$$

$y = 2{\cdot}000\,\pi$, and z the correction to the assumed annual motion.

Equations of Condition.

No.					Residuals.		Weight.
					I.	II.	
1	$+1{\cdot}0x$	$-0{\cdot}923y$	$-0{\cdot}741z$	$=\overset{R}{-0{\cdot}011}$	$\overset{R}{+0{\cdot}011}$	$\overset{R}{0{\cdot}000}$	1·0
2	1·0	−0·953	−0·727	−0·005	+0·017	+0·007	1·2
3	1·0	−0·969	−0·719	+0·008	+0·030	+0·020	0·7
4	1·0	−0·997	−0·697	−0·005	+0·017	+0·008	1·0
5	1·0	−1·002	−0·691	−0·002	+0·020	+0·011	0·7
6	1·0	−1·004	−0·686	−0·037	−0·014	−0·024	1·2
7	1·0	−1·007	−0·675	−0·040	−0·017	+0·001	1·0
8	1·0	−0·999	−0·653	−0·062	−0·039	−0·021	0·7
9	1·0	−0·992	−0·645	−0·029	−0·007	+0·011	1·2
10	1·0	−0·623	−0·527	−0·023	−0·008	−0·018	1·0
11	1·0	−0·467	−0·497	−0·023	−0·011	−0·022	0·7
12	1·0	−0·452	−0·494	+0·008	+0·020	+0·009	0·7
13	1·0	−0·422	−0·491	+0·014	+0·025	+0·015	0·7

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Equations of Condition—continued.

No.					Residuals.		Weight.
					I.	II.	
				R	R	R	
14	+1·0	−0·343	−0·475	+0·015	+0·025	+0·013	1·0
15	1·0	−0·326	−0·472	+0·023	+0·033	+0·021	1·2
16	1·0	+0·209	−0·385	−0·001	−0·002	+0·011	1·2
17	1·0	+0·242	−0·379	−0·003	−0·006	+0·007	1·2
18	1·0	+0·304	−0·369	−0·005	−0·009	−0·023	0·7
19	1·0	+0·445	−0·344	−0·026	−0·032	−0·020	1·2
20	1·0	+0·476	−0·338	−0·004	−0·012	+0·001	1·2
21	1·0	+0·578	−0·319	−0·016	−0·026	−0·025	1·2
22	1·0	+0·619	−0·311	−0·002	−0·012	−0·001	0·7
23	1·0	+0·753	−0·281	+0·030	+0·018	+0·028	0·7
24	1·0	+0·794	−0·270	−0·001	−0·015	−0·004	1·0
25	1·0	+0·908	−0·234	+0·000	−0·016	−0·017	1·2
26	1·0	+0·944	−0·218	+0·045	+0·028	+0·027	1·0
27	1·0	+0·973	−0·199	+0·038	+0·021	+0·020	1·0
28	1·0	+0·992	−0·174	+0·084	+0·067	+0·066	0·7
29	1·0	+0·992	−0·166	+0·022	+0·004	+0·003	1·0
30	1·0	+0·990	−0·158	−0·008	−0·026	−0·026	0·7
31	1·0	+0·987	−0·152	+0·030	+0·012	+0·012	1·0
32	1·0	+0·983	−0·147	−0·013	−0·030	−0·031	0·7
33	1·0	+0·955	−0·125	−0·008	−0·025	−0·026	1·2
34	1·0	+0·939	−0·117	−0·007	−0·024	−0·024	1·2
35	1·0	+0·900	−0·101	+0·028	+0·012	+0·012	0·7
36	1·0	+0·738	−0·053	+0·017	+0·004	+0·006	1·0
37	1·0	+0·678	−0·040	+0·031	+0·020	+0·022	0·7
38	1·0	+0·663	−0·037	+0·044	+0·033	+0·035	0·7
39	1·0	+0·624	−0·029	+0·022	+0·012	+0·014	0·7
40	1·0	+0·400	+0·012	−0·034	−0·039	−0·035	0·7
41	1·0	+0·130	+0·056	−0·003	−0·004	+0·002	0·7
42	1·0	−0·666	+0·191	−0·078	−0·062	−0·066	0·7
43	1·0	−0·905	+0·254	+0·004	+0·025	+0·023	1·0
44	1·0	−0·947	+0·270	−0·009	+0·013	+0·011	1·2

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Equations of Condition—continued.

No.					Residuals. I.	Residuals. II.	Weight.
				R	R	R	
45	+1·0	−0·987	+0·295	−0·062	−0·039	−0·012	1·0
46	1·0	−0·991	+0·298	−0·020	+0·003	+0·002	1·0
47	1·0	−0·994	+0·300	−0·017	+0·005	+0·004	0·7
48	1·0	−1·006	+0·317	−0·053	−0·030	−0·031	1·0
49	1·0	−0·999	+0·347	−0·006	+0·017	+0·016	1·0
50	1·0	−0·954	+0·380	−0·007	+0·015	+0·014	0·7

With equal weights for all observations the normals are found to be

$$\begin{array}{llll} +50{\cdot}00x & -\ 1{\cdot}71y & -11{\cdot}42z = & -0^{R}{\cdot}158 \\ -\ 1{\cdot}71 & +32{\cdot}64 & +\ 1{\cdot}69 & +\ {\cdot}665 \quad [nn] = 0{\cdot}0435 \\ -11{\cdot}42 & +\ 1{\cdot}69 & +\ 7{\cdot}92 & +\ {\cdot}017 \end{array}$$

and their solution leads to the following results according as z is assumed known or not:—

$$\begin{array}{llll} z = -0^{R}{\cdot}0086 \pm 0^{R}{\cdot}0074 & \text{or} & z = 0^{R} & \\ y \quad +\ {\cdot}0206 \quad {\cdot}0030 & & y \quad +\ {\cdot}0203 \pm 0^{R}{\cdot}0029 & \\ x \quad -\ {\cdot}0044 \quad {\cdot}0029 & & x \quad -\ {\cdot}0025 \quad {\cdot}0024 & \end{array}$$

$$\pi = 0''{\cdot}132 \pm 0''{\cdot}019 \qquad \pi = 0''{\cdot}131 \pm 0''{\cdot}019$$

Probable error, 1 obs. ± 0·217 Probable error, 1 obs. ± 0·216

The residuals for the two solutions are nearly identical, differing $0^{R}{\cdot}003$ at the outside; those for the latter are placed under Column I. Arranging them according to the different qualities of definition leads to the following values for the probable error of one observation :—

Images.	Observations.	Probable Error, 1 observation.	Steadiness.	Observations.	Probable Error, 1 observation.
1, 1–2, 2	27	±0″·181	2	13	±0″·172
2–3	13	·200	2–3	16	·187
3	9	·236	3	11	·188
			3–4	9	·243

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In doing this I have, however, not made use of observation No. 28, which was made under favourable circumstances as regards definition, but under exceptional ones in one sense, the stars being noted at the time as very faint from haze. If this observation is included the probable errors would become—

Images.		Steadiness.	
1, 1–2, 2	$\pm 0''.240$,	2	$\pm 0''.254$;

from which, in conjunction with the other values, but little effect of definition on the accuracy of the measures could be inferred. As, however, most of my series show such an effect, I have preferred to make use of the following little Table of weights, which roughly approximates to the theoretical weights which would be found without the observation in question:—

Images.

Steadiness.	1	1–2	2	2–3	3	3–4
1						
1–2						
2	1·2	1·2	1·2			
2–3			1·0	1·0		
3			1·0	0·7	0·7	
3–4			0·7	0·7	0·7	

The only exceptions I have made in applying these weights have been with reference to the observations No. 28 and No. 38, which consists only of eight pointings, both of which have received the weight of 0·7 instead of the higher one the table would give. With these weights, which are found beside the equations of condition, the normals become—

$$\begin{array}{llll} +46{\cdot}30x & -1{\cdot}96y & -11{\cdot}04z = -0{\cdot}187 & \\ -1{\cdot}96 & +30{\cdot}46 & +1{\cdot}59 \quad +{\cdot}575 & [p.nn] = 0{\cdot}0368 \\ -11{\cdot}04 & +1{\cdot}59 & +7{\cdot}59 \quad +{\cdot}042 & \end{array}$$

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leading to the values of the unknowns—

	R	R		R	R
$z =$	$-0''.0050$	$\pm 0''.0071$,	or with $z =$	$0''$	
y	$+ .0192$	$.0029$	y	$+0''.0187$	$\pm 0''.0028$
x	$- .0044$	$.0028$	z	$- .0032$	$.0023$

$\pi = 0''.124 \pm 0''.019$, Probable error, 1 obs. of weight 1 $\pm 0''.203$,

$\pi = 0''.121 \pm 0''.018$ Probable error, 1 obs. of weight 1 $\pm 0''.201$

which differ but slightly from those of the previous solutions. Under the assumption of perfect freedom of the series from systematic error a parallax of about one-eighth of a second would seem well established.

The possibility of systematic error in this series is not entirely excluded, however, for the same reason as in my first *Sirius* series, viz. a small inequality in magnitude of ϵ *Indi* as seen through the screen and the two comparison stars. Star *a* and the reduced ϵ *Indi* appeared of nearly the same brilliancy, so that there was about a half magnitude of difference between the latter and star *b*, which might give rise to systematic errors, varying with the inclination of the line under observation to the horizon. The following little Table gives this inclination (p–q) for different hour angles :—

Hour Angle.	East.		West.	
	Sidereal Time.	$p-q$.	Sidereal Time.	$p-q$.
h	h	°	h	°
0	21·9	64	21·9	64
1	20·9	94	22·9	34
2	19·9	118	23·9	10
3	18·9	136	0·9	352
4	17·9	150	1·9	338
5	16·9	162	2·9	326
6	15·9	174	3·9	314

From these figures it will be seen that *East* of the Meridian up to three hours' hour angle ($18^h\ 9^m$ Sid. Time) the line joining the stars is more nearly vertical than horizontal, and after this time the contrary is the case.

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Remembering my rule as to the position of the observer's head, the observations *East* will, therefore, have to be divided into two groups; and, as there are fortunately no observations for which the mean time falls between $18^h\ 30^m$ and $19^h\ 15^m$, this division can be carried out for all the observations with almost absolute certainty. *West* of the Meridian, as there are no observations before $23^h\ 50^m$, the whole series will have been made in one position of the head, with the exception of No. 41; in the following solutions this observation has been inadvertently retained; it leaves, however, a very small residual, so that its rejection would not have altered the result appreciably.

I, therefore, have formed the normals anew, assuming two modes of bisection to have been employed *East*, and a third *West* of the Meridian. This gives—

Normals.

					R	
$+19{\cdot}10x_E$	$+\ 0{\cdot}00x'_E$	$+\ 0{\cdot}00x_W$	$-14{\cdot}60y$	$-4{\cdot}84z$	$=-0{\cdot}204$	
$+\ 0{\cdot}00$	$+11{\cdot}10$	$+\ 0{\cdot}00$	$-\ 0{\cdot}49$	$-4{\cdot}03$	$-\ {\cdot}204$	
$+\ 0{\cdot}00$	$+\ 0{\cdot}00$	$+16{\cdot}10$	$+13{\cdot}13$	$-2{\cdot}16$	$+\ {\cdot}220$	$[p.nn] = 0{\cdot}0368$
$-14{\cdot}60$	$-\ 0{\cdot}49$	$+13{\cdot}13$	$+30{\cdot}46$	$+1{\cdot}59$	$+\ {\cdot}575$	
$-\ 4{\cdot}84$	$-\ 4{\cdot}03$	$-\ 2{\cdot}16$	$+\ 1{\cdot}59$	$+7{\cdot}59$	$+\ {\cdot}042$	

Solution.

$z = -0{\cdot}0087 \pm 0{\cdot}0069$ (R)			or with $z = 0$ (R)		
y	$+\ {\cdot}0263$	${\cdot}0050$	y	$+\ {\cdot}0268 \pm 0{\cdot}0050$	
x_W	$-\ {\cdot}0089$	${\cdot}0054$	x_W	$-\ {\cdot}0083$	${\cdot}0055$
x'_E	$-\ {\cdot}0203$	${\cdot}0052$	x'_E	$-\ {\cdot}0172$	${\cdot}0044$
x_E	$+\ {\cdot}0072$	${\cdot}0054$	x_E	$+\ {\cdot}0098$	${\cdot}0051$

$\pi = 0''{\cdot}170 \pm 0''{\cdot}032$	$\pi = 0''{\cdot}173 \pm 0''{\cdot}032$
Probable error, 1 obs. of weight 1 $\pm 0{\cdot}190$	Probable error, 1 obs. of weight 1 $\pm 0{\cdot}190$

The residuals for the solution with z are found in the Column II. of *Residuals*, and show some improvement as regards distribution of signs compared with the former solution, the probable error of one observation being at the same time slightly diminished. The value for the parallax agrees within the limits assigned by the probable errors with that of the former solution, and the correction for proper motion is, as before, small, and exceeds but little its probable error.

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As a final test, I will deduce the parallax from each of the three groups independently. For the fourth equation in the above group must be placed the following three:—

$$\begin{array}{llll} -14{\cdot}60x_{\text{R}} & +13{\cdot}15y_{\text{R}} & +2{\cdot}99z = & +0{\cdot}^{\text{R}}204 \\ -\ 0{\cdot}49x'_{\text{R}} & +\ 5{\cdot}79y'_{\text{R}} & +0{\cdot}55 & +\ {\cdot}173 \\ +13{\cdot}13x_{\text{W}} & +11{\cdot}52y_{\text{W}} & -1{\cdot}95 & +\ {\cdot}201 \end{array}$$

solving with and without z gives the following results:—

z	$= -0{\cdot}^{\text{R}}0099 \pm 0{\cdot}^{\text{R}}0072$		or z	$= 0$	^{R}
y_{W}	+ ·0283	·0166	y_{W}	+ ·0260	$\pm$ 0·0166
y'_{R}	+ ·0279	·0062	y'_{R}	+ ·0285	·0062
y_{R}	+ ·0276	·0107	y_{R}	+ ·0241	·0106
x_{W}	− ·0108	·0182	x_{W}	− ·0076	·0139
x'_{R}	− ·0207	·0059	x'_{R}	− ·0171	·0045
x_{R}	+ ·0079	·0111	x_{R}	+ ·0077	·0088

$\pi = 0''{\cdot}182$	$\pm 0''{\cdot}107$	from W. obs.		$\pi = 0''{\cdot}168$	$\pm 0''{\cdot}107$
·180	·040	„ E.′	„	·184	·040
·172	·069	„ E.	„	·156	·068

Probable error, 1 obs. of weight 1, both solutions $0''{\cdot}192$

Of course the extremely close agreement of the three values of the parallax is to a large extent a matter of chance considering the amount of uncertainty each separate value is subject to. Still it cannot be denied that each of the three groups, extending, the two on the East of the Meridian, each over about three hours of hour angle, and that on the West over about five hours, do bear unmistakable traces of a parallax approximating in amount to that given by the series in its entirety. I am, therefore, inclined to think that the series has suffered but little, if any, from systematic errors of the kind described, and hence to accept as final the result of the solution which leaves them out of consideration, viz.:—

$$\pi = 0^{h}{\cdot}12 \pm 0''{\cdot}019.$$

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§ 9. *Parallax of Lacaille* 9352. Gill.

Writing from Cordoba on January 25, 1881, Dr. Gould announced (*Ast. Nach.* No. 2377) his discovery that a star of 7·5 magnitude in *Piscis Austrinus* (*Lacaille* 9352) has an annual proper motion amounting nearly to 7″ of arc on the great circle, an apparent motion inferior only (and that by less than $\frac{1}{10}$ of a second of arc) to that of Argelander's celebrated star, 1830 *Groombridge* in *Ursa Major*.

When this announcement reached the Cape, I determined to relinquish a series of observations which I had commenced for determining the parallax of β *Hydri*, in order to undertake the more immediately interesting and important research of the parallax of this star.

The following are Dr. Gould's results:—

Annual proper motion of Lacaille 9352 in R.A. $+0^{s}\cdot5672$

" " " " in Decl. $+1''\cdot3058$

The annual variations reckoned from the epoch 1875·0 are

in R.A. $+ 3^{s}\cdot9054 - 0^{s}\cdot000266t$

in Decl. $+20''\cdot6256 + 0''\cdot001226t$

and with these data, the existing observations are represented as follows:—

Authority.	No. of Years from Epoch.	1875·0		No. of Obs.
		α	δ	
		h m s	° ′ ″	
Lacaille	−122·5	22 57 47·14	−36 34 20·2	
Wash. Zones ...	− 28·3	47·90	29·3	
" Obs. ...	− 9·3	47·27		
" " ...	− 5·3	47·11	18·7	
Cordoba Zones ...	+ 2·3	47·10	19·0	
" Obs. ...	+ 1·9	47·12	20·2	4
Cape Cat. 1880 ...	+ 2·84	47·14	20·4	3
" Obs. 1882 ...	+ 7·69	47·09	20·2	10

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It is evidently unnecessary to change Dr. GOULD'S estimate of the proper motion on account of the recent Cape results. Such change would at most be very insignificant; it would in reality depend on more or less arbitrary assumptions as to the relative weights and systematic corrections of the various authorities, and on neither of these points have we, as yet, sufficient data.

There are no comparison stars which are remarkably favourable. The pair selected, α and β, shown in the figure (Plate I.) appears to be decidedly the best. The position angles of these stars from *Lacaille* 9352 differ almost exactly 180°, and the line joining them is nearly in the major axis of the parallactic ellipse. The difference of the distances amounts to nearly $\frac{1}{4}$ of their sum—a larger proportion than has been admitted into any of the other accompanying researches. The magnitudes of α and β are 7·9 and 7·3 repectively, and in this respect are not very unfavourable, since the magnitude of *Lacaille* 9352 (7·5 mag.) is between them. No screen has been used during this series of observations, but it would certainly have been better to use a screen reducing *Lacaille* 9352 to the brightness of α, and to have employed no screen in the observations of β.

The following, so far as I know, are all the existing Meridian observations of the comparison stars.

The star α appears to have sensible proper motion.

To investigate the systematic errors of the Washington Meridian observations of this star, I have reduced the places of twenty similar stars of the Cape Catalogue 1880, between $22^h\ 30^m$ and $23^h\ 30^m$ of R.A., and of Declination $-34°$ to $-40°$, which have also been observed at Washington, and find, for such stars, that YARNALL'S Catalogue requires the following corrections to STONE:—

$$\text{in R.A.} + 0^s\cdot08 \qquad \text{in Decl.} - 0''\cdot44$$

Applying these corrections and a proper motion of $+0^s\cdot019$ in R.A. the existing Meridian observations are represented as follows for the Equinox of 1882:—

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Star α.

Authority.	Epoch.	1882·0		No. of Obs.
		α	δ	
		h m s	° ′ ″	
Yarnall 10077 ...	1866·2	22 49 34·91	−37 18 26·1	2
Cordoba Obs.* ...	1878·8	34·93	25·8	4
Cape Obs. ...	1882·7	34·82	25·9	10

For the star β the proper motion cannot be deduced from existing data; we can only conclude that it is small.

Star β.

Authority.	Epoch.	1882·0		No. of Obs.
		α	δ	
		h m s	° ′ ″	
Cordoba Obs.* ...	1878·9	23 3 47·99	−36 2 17·5	3
,, ...	1879·8	48·00	16·9	3
Cape Obs. ...	1882·7	47·98	17·8	10

At the Cape in 1882, *Lacaille* 9352 and the comparison stars were all observed by Mr. George Maclear with the Transit-Circle on each of ten nights. The results, reduced with the above proper motions to 1882·0, I adopt as definitive, viz.:—

	h m s	° ′ ″
α	22 49 34·815	−37 18 25·88
Lacaille 9352 ...	22 58 14·420	−36 31 55·75
β	23 3 47·977	−36 2 17·77

Whence the distances and position angles of α and β relative to *Lacaille* 9352 are

	Distance 1882·0	Position Angle 1882·0
α	$68''27+6''770t$	$245°88-0°0161t$
β	$4407-6·780t$	$66·21+·0176t$

* Kindly communicated by Dr. Gould.

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The somewhat doubtful proper motion of α is not included in these results, but the annual variations of position angle include the effect of precession.

The corresponding proper motions in terms of R are

	R
For distance from α	+0·5263
„ „ β	− ·5270

The parallax factors are

Distance α.	Distance β.
0·9997 R cos ($\odot - 61^\circ 35$)	0·9996 R cos ($\odot - 241^\circ 50$)

Hence for $\alpha - \beta$:

$$1{\cdot}9993\ \mathrm{R} \cos (\odot - 61^\circ 43)$$

The effect of parallax on the sum of the distances is quite insensible.

The aberration constants are

Distance α.	Distance β.
log. a − 7·1030, log. b − 7·2990	log. a − 6·8780, log. b − 7·0964

The observations were begun in September 1881 with the intention of carrying them on continuously throughout the whole year, but it was soon found that this could not be done without neglecting some other portion of our programme. Accordingly the after observations were confined to epochs about the maximum and minimum of parallax, and I brought the first series to a close in May 1883, with confident belief in the freedom of such observations from systematic error, and without the intention to renew the work. But, as the comparison stars in question are the most unsymmetrical, both as to distance and magnitude, of any of the pairs which I have observed, I afterwards resolved to undertake another series in September 1883 (when the star *Lacaille* 9352 culminates about midnight), in order, if possible, to set at rest the important question as to whether, in such a case, systematic error, depending on the hour angle, exists.

The weather during September and October 1883 was exceptionally unfavourable (indeed the winter months of 1883 have been by far the most cloudy I have yet experienced at the Cape). It is certain that during the six weeks in question I did not lose a single opportunity of observing at the required sidereal times, and yet I only managed to secure observations on

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ten evenings and ten mornings. These constitute the second series of observations in the present investigation. The observations are given in the following Tables, reduced after the same manner as the preceding investigations:—

In forming the values of $\alpha-\beta$, S_0 has been taken

$$= 873^{R}\cdot1193,\ D_0 = 188^{R}\cdot0300,$$

and the correction of $\alpha-\beta$ to normal scale value

$$= \Delta D = 0\cdot215\ (S_0 - S).$$

Series I.

No.		Sidereal Time.	Definition. I.	Definition. S.	Temperature.	α	β	$\alpha-\beta+\Delta D$.
	1881	h m			°	R	R	R
1	Sept. 14	2 29	3	3	49·0	530·5787	342·5522	188·0240
2	Oct. 6	1 57	1–2	1–2	50·0	·5659	·5437	8·0243 ½ set
3	16	1 42	1–2	1–2	59·3	·5993	·5719	8·0162
4	31	3 16	3	3	50·0	·5224	·5564	7·9747 ½ set
5	Nov. 3	2 6	2	2	59·5	·5654	·5644	7·9987
6	5	2 25	—	—	60·0	·5402	·5262	8·0254
7	19	2 22	2–3	2–3	56·8	·5398	·5294	8·0212
8	20	3 37	2–3	2	55·8	·5289	·5662	7·9679 ½ set
9	26	1 40	2	2–3	55·7	·5552	·5488	8·0097 ½ set
10	29	2 41	2	3	55·3	·6438	·6096	8·0054
11	Dec. 8	2 23	1–2	2–3	56·0	·5740	·5588	8·0123
12	10	4 2	2–3	2–3	61·8	·5677	·5812	7·9801
13	13	3 14	3	3	62·0	·6124	·5862	8·0092
	1882							
14	May 2	19 18	1–2	1–2	50·3	·5866	·4930	8·1022
15	5	19 53	2	2	60·8	·5322	·5178	8·0293 ½ set
16	7	18 55	1–2	2–3	52·0	·5884	·5182	8·0729
17	9	18 55	1–2	1–2	56·3	·5985	·5074	8·0940
18	18	20 56	2	2	42·5	·5997	·5118	8·0896 ½ set
19	19	18 59	2	2–3	47·0	·5706	·5182	8·0590
20	23	18 25	2	2	55·5	·5814	·4887	8·1033 ½ set
21	26	19 16	—	—	60·0	·5599	·4889	8·0862
22	Nov. 24	2 14	3	3	59·3	·5444	·5560	7·9925
23	27	1 4	2	2–3	62·3	·5402	·5757	7·9652
24	28	2 22	2–3	2–3	64·8	·5654	·5917	7·9656
25	29	1 58	—	—	65·0	·5500	·5825	7·9647

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Series I.—continued.

No.		Sidereal Time.	Definition.		Temperature.	α	β	α−β+ΔD.
			I.	S.				
	1882	h m			°			
26	Dec. 4	2 10	1–2	1–2	58·7	530·5023	342·5529	187·9632
27	9	2 37	2–3	2–3	70·5	·5557	·5527	8·0054
28	13	2 47	2–3	2–3	57·0	·5535	·5381	8·0214
	1883							
29	April 28	19 51	—	—	56·0	·6137	·5498	8·0544
30	30	19 26	2	2	49·5	·6114	·5404	8·0640
31	May 12	19 47	1–2	2	46·0	·6134	·5430	8·0624
32	19	20 9	—	—	41·0	·6273	·5440	8·0722

Series II.

No.		Sidereal Time.	Definition.		Temperature.	α	β	α−β+ΔD.
			I.	S.				
	1883	h m			°			
33	Sept. 13	19 20	2	2	52·5	530·5752	342·5723	187·9968
34	14	18 54	2	2	53·0	·5771	·5790	7·9902 ½ set
35	14	3 25	2–3	2–3	47·8	·6063	·5731	8·0203
36	16	19 16	2–3	2–3	54·5	·5627	·5623	7·9992
37	19	19 9	3	3	52·5	·5615	·5576	8·0039
38	19	2 43	3	3	52·8	·5720	·5551	8·0131 ½ set
39	20	19 18	2	2	56·0	·5642	·5687	7·9926
40	20	3 5	2	2	53·8	·5835	·5666	8·0103
41	24	19 29	—	—	56·0	·5144	·5478	7·9789
42	24	3 7	1–2	1–2	46·3	·5629	·5503	8·0139
43	25	19 15	2–3	2–3	59·0	·5469	·5605	7·9890
44	25	3 13	3	2	56·8	·5768	·5780	7·9912 ½ set
45	29	3 7	2–3	2–3	43·5	·5642	·5746	7·9854
46	30	19 32	3	3	52·8	·5467	·5342	8·0208 ½ set
47	Oct. 3	19 58	3	3	62·4	·5564	·5427	8·0180
48	3	1 58	1–2	2	53·8	·5881	·5559	8·0290
49	5	20 19	3	3	57·5	·5380	·5495	7·9953
50	5	2 12	2–3	2–3	57·3	·5162	·5852	7·9348
51	12	2 8	2	2	47·0	·5473	·5548	7·9963
52	14	2 38	—	—	58·0	·5455	·5746	7·9707

An inspection of the above Tables will show that the observations East of the Meridian, with the single exception of one "half set," No. 20 ($18^h\ 25^m$),

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have been made between $18^h\ 55^m$ and $20^h\ 56^m$, or within a range of about 2^h in hour angle, and also that the observations West of the Meridian, with the exception of No. 23 ($1^h\ 4^m$) and No. 12 ($4^h\ 2^m$), have been made between $1^h\ 40^m$ and $3^h\ 37^m$ Sidereal time—*i.e.* also within a range of 2^h of hour angle.

In discussing the observations for systematic error it therefore appears only necessary to divide the observations into two groups—those made East and those made West of the Meridian.

Denoting the correction of the assumed mean value of $\alpha-\beta+\Delta D$ ($188^R{\cdot}0300$) by x_E when the equation results from an observation made East of the Meridian, and by x_W when the equation results from observations West of it, the following equations are obtained. The equations depending on half sets of observation are marked $\frac{1}{2}$ in the column p:—

Equations of Condition. Series I.

No.					I.	II.	p
1		x_W	$-0{\cdot}298y$	$-0{\cdot}360z = -0{\cdot}006$	$-{\cdot}009$	$-{\cdot}006$	
2		x_W	$-{\cdot}238$	$-{\cdot}675 \quad -{\cdot}006$	$+{\cdot}007$	$+{\cdot}006$	$\frac{1}{2}$
3		x_W	$-{\cdot}210$	$-{\cdot}789 \quad -{\cdot}014$	$+{\cdot}004$	$+{\cdot}001$	
4		x_W	$-{\cdot}169$	$-{\cdot}915 \quad -{\cdot}055$	$-{\cdot}030$	$-{\cdot}029$	$\frac{1}{2}$
5		x_W	$-{\cdot}161$	$-{\cdot}933 \quad -{\cdot}031$	$-{\cdot}005$	$-{\cdot}004$	
6		x_W	$-{\cdot}155$	$-{\cdot}943 \quad -{\cdot}005$	$+{\cdot}021$	$+{\cdot}022$	
7		x_W	$-{\cdot}117$	$-{\cdot}985 \quad -{\cdot}009$	$+{\cdot}020$	$+{\cdot}021$	
8		x_W	$-{\cdot}114$	$-{\cdot}987 \quad -{\cdot}062$	$-{\cdot}033$	$-{\cdot}032$	$\frac{1}{2}$
9		x_W	$-{\cdot}098$	$-{\cdot}985 \quad -{\cdot}020$	$+{\cdot}009$	$+{\cdot}010$	$\frac{1}{2}$
10		x_W	$-{\cdot}090$	$-{\cdot}980 \quad -{\cdot}025$	$+{\cdot}004$	$+{\cdot}005$	
11		x_W	$-{\cdot}066$	$-{\cdot}949 \quad -{\cdot}018$	$+{\cdot}010$	$+{\cdot}011$	
12		x_W	$-{\cdot}060$	$-{\cdot}939 \quad -{\cdot}050$	$-{\cdot}022$	$-{\cdot}022$	
13		x_W	$-{\cdot}052$	$-{\cdot}921 \quad -{\cdot}021$	$+{\cdot}006$	$+{\cdot}007$	
14	x_E		$+{\cdot}033$	$+{\cdot}954 \quad +{\cdot}072$	$+{\cdot}022$	$+{\cdot}023$	
15	x_E		$+{\cdot}341$	$+{\cdot}971 \quad -{\cdot}001$	$-{\cdot}052$	$-{\cdot}051$	$\frac{1}{2}$
16	x_E		$+{\cdot}347$	$+{\cdot}980 \quad +{\cdot}043$	$+{\cdot}013$	$-{\cdot}007$	
17	x_E		$+{\cdot}352$	$+{\cdot}984 \quad +{\cdot}064$	$+{\cdot}013$	$+{\cdot}014$	
18	x_E		$+{\cdot}377$	$+1{\cdot}010 \quad +{\cdot}060$	$+{\cdot}008$	$+{\cdot}009$	$\frac{1}{2}$

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Equations of Condition. Series I.—continued.

No.					I.	II.	p
19	x_K	$+0\cdot379y$	$+1\cdot011z$	$=+0\cdot029$	$-\cdot023$	$-\cdot022$	
20	x_K	$+\cdot390$	$+1\cdot013$	$+\cdot073$	$+\cdot021$	$+\cdot022$	$\frac{1}{2}$
21	x_K	$+\cdot399$	$+1\cdot010$	$+\cdot056$	$+\cdot005$	$+\cdot005$	
22	x_W	$+\cdot896$	$-0\cdot987$	$-\cdot038$	$+\cdot009$	$+\cdot005$	
23	x_W	$+\cdot905$	$-\cdot993$	$-\cdot065$	$-\cdot017$	$-\cdot021$	
24	x_W	$+\cdot907$	$-\cdot982$	$-\cdot064$	$-\cdot017$	$-\cdot021$	
25	x_W	$+\cdot910$	$-\cdot980$	$-\cdot065$	$-\cdot018$	$-\cdot022$	
26	x_W	$+\cdot924$	$-\cdot966$	$-\cdot067$	$-\cdot020$	$-\cdot024$	
27	x_W	$+\cdot937$	$-\cdot945$	$-\cdot025$	$+\cdot021$	$+\cdot017$	
28	x_W	$+\cdot948$	$-\cdot923$	$-\cdot009$	$+\cdot037$	$+\cdot032$	
29	x_K	$+1\cdot322$	$+\cdot928$	$+\cdot024$	$-\cdot007$	$-\cdot011$	
30	x_K	$+1\cdot328$	$+\cdot941$	$+\cdot034$	$+\cdot003$	$-\cdot001$	
31	x_K	$+1\cdot361$	$+\cdot998$	$+\cdot032$	$-\cdot001$	$-\cdot005$	
32	x_K	$+1\cdot380$	$+1\cdot011$	$+\cdot042$	$+\cdot008$	$+\cdot005$	

Equations of Condition. Series II.

No.					II.	p
33	x_K	$+1\cdot699y$	$-0\cdot330z$	$=-0\cdot033$	$-\cdot007$	
34	x_K	$+1\cdot702$	$-\cdot346$	$-\cdot040$	$-\cdot013$	$\frac{1}{2}$
35	x_W	$+1\cdot703$	$-\cdot352$	$-\cdot010$	$+\cdot016$	
36	x_K	$+1\cdot707$	$-\cdot379$	$-\cdot031$	$-\cdot005$	
37	x_K	$+1\cdot715$	$-\cdot425$	$-\cdot026$	$+\cdot004$	
38	x_W	$+1\cdot716$	$-\cdot430$	$-\cdot017$	$+\cdot013$	$\frac{1}{2}$
39	x_K	$+1\cdot718$	$-\cdot441$	$-\cdot037$	$-\cdot006$	
40	x_W	$+1\cdot719$	$-\cdot446$	$-\cdot020$	$+\cdot011$	
41	x_K	$+1\cdot729$	$-\cdot501$	$-\cdot051$	$-\cdot017$	
42	x_W	$+1\cdot730$	$-\cdot505$	$-\cdot016$	$+\cdot017$	
43	x_K	$+1\cdot732$	$-\cdot516$	$-\cdot041$	$-\cdot006$	
44	x_W	$+1\cdot733$	$-\cdot520$	$-\cdot039$	$-\cdot005$	$\frac{1}{2}$
45	x_W	$+1\cdot744$	$-\cdot577$	$-\cdot045$	$-\cdot008$	
46	x_K	$+1\cdot745$	$-\cdot586$	$-\cdot009$	$+\cdot029$	$\frac{1}{2}$

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Equations of Condition. Series II.—**continued.**

No.						II.	*p*
47	x_E		+1·754	− ·626	= −0·012	+·028	
48		x_W	+1·754	− ·629	− ·001	+·038	
49	x_E		+1·759	− ·653	− ·035	+·006	
50		x_W	+1·760	− ·655	− ·095	−·055	
51		x_W	+1·779	− ·740	− ·034	+·010	
52		x_W	+1·784	− ·762	− ·059	−·014	

From the first series, giving equal weights to all the equations which depend on "complete sets" of observations, and half weight to equations 2, 4, 8, 9, 15, 18, and 20, which depend on "half sets" of observations, the normals are—

10·500x_E		+ 7·755y	+10·314z	= +0·462
	18·000x_W	+ 4·909	−16·356	− ·584
7·755	+14·909	+14·303	+ 2·557	+ ·024
10·314	−16·356	+ 2·557	+25·395	+1·012

From these equations it is obviously impossible to determine z with any reliable weight, because x_E occurs only in the original equations, where the coefficients of z has the + sign, and x_W in those equations where the coefficients of z is negative. But if we suppose the observations to be free from systematic error, that is, write—

$$x = x_E = x_W$$

we obtain

$$[p.vv] = 0{\cdot}00890 \qquad \epsilon^2 = 0{\cdot}000308$$

x =	+0·0133,	Weight 14·52,	Probable error	±	0·0031
y	− ·0181	„ 7·54	„	„	·0043
z	+ ·0448	„ 20·95	„	„	·0026

$$\pi = 0''{\cdot}288 \pm 0''{\cdot}017$$

and the probable error of one observation

$$= \pm 0{\cdot}0118 = \pm 0''{\cdot}152$$

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The residuals from this solution are given in the column marked I. beside the equations.

From the second series, giving half weight to the equations 34, 38, 44, and 46, which depend on half sets of observations, we obtain the normals—

$9{\cdot}000x_E$		$+15{\cdot}537y$	$-\ 4{\cdot}337z$	$=-0{\cdot}291$
	$9{\cdot}000x_W$	$+15{\cdot}698$	$-\ 5{\cdot}141$	$-0{\cdot}308$
$15{\cdot}537$	$+15{\cdot}698$	$+54{\cdot}209$	$-16{\cdot}504$	$-1{\cdot}041$
$-\ 4{\cdot}337$	$-\ 5{\cdot}141$	$-16{\cdot}504$	$+\ 5{\cdot}286$	$+0{\cdot}330$

Adding these normals to the corresponding normals from the first series, and solving the normals from the combined series so formed, we obtain—

$$[p.vv] = 0{\cdot}0164 \qquad \epsilon^2 = 0{\cdot}000342$$

x_E	$= +0{\cdot}0113$,	Weight	$7{\cdot}44$,	Probable error	$\pm\ {}^{R}0{\cdot}0046$
x_W	$+\ {\cdot}0123$	„	$10{\cdot}04$	„	„ ${\cdot}0039$
y	$-\ {\cdot}0134$	„	$23{\cdot}09$	„	„ ${\cdot}0026$
z	$+\ {\cdot}0441$	„	$10{\cdot}86$	„	„ ${\cdot}0038$

$$\pi = 0{\cdot}''284 \pm 0{\cdot}''024$$

and the probable error of one observation

$$= \pm\ {}^{R}0{\cdot}0125 = \pm\ 0{\cdot}''160$$

The representation of this solution is given in Column II. beside the equations of condition.

It is very satisfactory to find thus that there is no reason to suspect the existence of a real systematic difference between observations made East and West of the Meridian, the difference for $x_W - x_E$ being

$$+0{\cdot}0010\ (= 0{\cdot}''013)$$

a quantity much within the probable error of its determination.

A glance at the residuals will show that there is no connection between

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quality of the definition and the amount of the corresponding accidental errors. I am inclined to attribute the larger errors of this series, as a whole, to the difficulty of observing the star α in the neighbourhood of *Lacaille* 9352, when the sky was in the least degree obscured by haze or fog. Unfortunately, I have no complete record of these conditions; the safest course seems to be to give to all complete observations equal weight, and to all "half sets," half weight, as has been already done in the past discussion.

But there is another method of forming the equations, which appears to be peculiarly applicable to the present case—viz., instead of correcting the observed difference of the distances for abnormal scale-value from the sum of the distances, we may multiply the greater distance and the corresponding parallax factor by such a fraction as shall, in the mean, equalise the two distances. In the last solution we adopted for approximate mean values—

$$\overset{R}{\alpha+\beta = 873\cdot1193}$$
$$\alpha-\beta = 188\cdot0300$$

whence

$$\overset{R}{\alpha = 530\cdot5747} \qquad \overset{R}{\beta = 342\cdot5447}$$

In the present case this would be equivalent to multiplying the distance α by $\frac{342\cdot5447}{530\cdot5747}$. The effect is still to eliminate the influences of any abnormal instantaneous scale-value from the remaining difference of the distances; but the measures of distance from α thus receive a weight of $\left(\frac{342\cdot5447}{530\cdot5747}\right)^2$, or of about 0·42, whilst the measures from β have the weight 1·0. But the star β is a bright and easy object for measurement, differing very slightly in magnitude from *Lacaille* 9352, whilst the star α approaches the limit of magnitude at which tolerably accurate measures can be made. In view of the greater distance and the faintness of α, this method probably gives a result more in accordance with the relative precision of the observations than when both observations receive equal weight.

The results of the observations have accordingly been reduced on this plan, and lead to the following equations of condition:—

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Equations of Condition. Series I.

No.						I.	II.	p
1		x_W	$-0\cdot298y$	$-0\cdot591\pi$	$=-\cdot005$	$-0\cdot007$	$-\cdot007$	
2		x_W	$-\cdot238$	$-1\cdot109$	$-\cdot005$	$+\cdot005$	$+\cdot005$	$\frac{1}{2}$
3		x_W	$-\cdot210$	$-1\cdot298$	$-\cdot011$	$+\cdot004$	$+\cdot004$	
4		x_W	$-\cdot169$	$-1\cdot505$	$-\cdot045$	$-\cdot025$	$-\cdot025$	$\frac{1}{2}$
5		x_W	$-\cdot161$	$-1\cdot535$	$-\cdot026$	$-\cdot005$	$-\cdot005$	
6		x_W	$-\cdot155$	$-1\cdot552$	$-\cdot004$	$+\cdot017$	$+\cdot017$	
7		x_W	$-\cdot117$	$-1\cdot631$	$-\cdot007$	$+\cdot016$	$+\cdot016$	
8		x_W	$-\cdot114$	$-1\cdot623$	$-\cdot051$	$-\cdot028$	$-\cdot028$	$\frac{1}{2}$
9		x_W	$-\cdot098$	$-1\cdot620$	$-\cdot017$	$+\cdot006$	$+\cdot006$	$\frac{1}{2}$
10		x_W	$-\cdot090$	$-1\cdot611$	$-\cdot020$	$+\cdot003$	$+\cdot003$	
11		x_W	$-\cdot066$	$-1\cdot561$	$-\cdot015$	$+\cdot007$	$+\cdot007$	
12		x_W	$-\cdot060$	$-1\cdot544$	$-\cdot041$	$-\cdot019$	$-\cdot019$	
13		x_W	$-\cdot052$	$-1\cdot515$	$-\cdot017$	$+\cdot005$	$+\cdot004$	
14	x_E		$+\cdot333$	$+1\cdot571$	$+\cdot059$	$+\cdot017$	$+\cdot017$	
15	x_E		$+\cdot341$	$+1\cdot597$	$-\cdot001$	$-\cdot041$	$-\cdot043$	$\frac{1}{2}$
16	x_E		$+\cdot347$	$+1\cdot613$	$+\cdot035$	$-\cdot008$	$-\cdot007$	
17	x_E		$+\cdot352$	$+1\cdot619$	$+\cdot053$	$+\cdot010$	$+\cdot011$	
18	x_E		$+\cdot377$	$+1\cdot662$	$+\cdot049$	$+\cdot006$	$+\cdot006$	$\frac{1}{2}$
19	x_E		$+\cdot379$	$+1\cdot664$	$+\cdot024$	$-\cdot019$	$-\cdot019$	
20	x_E		$+\cdot390$	$+1\cdot665$	$+\cdot060$	$+\cdot017$	$+\cdot017$	$\frac{1}{2}$
21	x_E		$+\cdot399$	$+1\cdot662$	$+\cdot046$	$+\cdot003$	$+\cdot003$	
22		x_W	$+\cdot896$	$-1\cdot623$	$-\cdot031$	$+\cdot004$	$+\cdot004$	
23		x_W	$+\cdot905$	$-1\cdot634$	$-\cdot053$	$-\cdot017$	$-\cdot018$	
24		x_W	$+\cdot907$	$-1\cdot616$	$-\cdot053$	$-\cdot018$	$-\cdot018$	
25		x_W	$+\cdot910$	$-1\cdot613$	$-\cdot054$	$-\cdot019$	$-\cdot019$	
26		x_W	$+\cdot924$	$-1\cdot590$	$-\cdot055$	$-\cdot020$	$-\cdot020$	
27		x_W	$+\cdot937$	$-1\cdot555$	$-\cdot020$	$+\cdot014$	$+\cdot014$	
28		x_W	$+\cdot948$	$-1\cdot519$	$-\cdot007$	$+\cdot027$	$+\cdot026$	
29	x_E		$+1\cdot322$	$+1\cdot526$	$+\cdot020$	$-\cdot009$	$-\cdot009$	
30	x_E		$+1\cdot328$	$+1\cdot548$	$+\cdot028$	$-\cdot001$	$-\cdot001$	
31	x_E		$+1\cdot361$	$+1\cdot641$	$+\cdot027$	$-\cdot004$	$-\cdot004$	
32	x_E		$+1\cdot380$	$+1\cdot663$	$+\cdot035$	$+\cdot004$	$+\cdot004$	

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Equations of Condition. Series II.

No.						I.	II.	p
33	x_E		$+1\cdot699y$	$-0\cdot543\pi$	$=-0\cdot027$	$-\cdot006$	$-\cdot005$	
34	x_E		$+1\cdot702$	$-\cdot570$	$-\cdot033$	$-\cdot011$	$-\cdot010$	$\frac{1}{2}$
35		x_W	$+1\cdot703$	$-\cdot578$	$-\cdot008$	$+\cdot014$	$+\cdot013$	
36	x_E		$+1\cdot707$	$-\cdot623$	$-\cdot025$	$-\cdot002$	$-\cdot001$	
37	x_E		$+1\cdot715$	$-\cdot700$	$-\cdot021$	$+\cdot004$	$+\cdot005$	
38		x_W	$+1\cdot716$	$-\cdot707$	$-\cdot012$	$+\cdot013$	$+\cdot012$	$\frac{1}{2}$
39	x_E		$+1\cdot718$	$-\cdot725$	$-\cdot031$	$-\cdot005$	$-\cdot005$	
40		x_W	$+1\cdot719$	$-\cdot733$	$-\cdot016$	$+\cdot010$	$+\cdot009$	
41	x_E		$+1\cdot729$	$-\cdot823$	$-\cdot042$	$-\cdot014$	$-\cdot013$	
42		x_W	$+1\cdot730$	$-\cdot831$	$-\cdot013$	$+\cdot015$	$+\cdot014$	
43	x_E		$+1\cdot732$	$-\cdot848$	$-\cdot034$	$-\cdot005$	$-\cdot005$	
44		x_W	$+1\cdot733$	$-\cdot856$	$-\cdot032$	$-\cdot003$	$-\cdot004$	$\frac{1}{2}$
45		x_W	$+1\cdot744$	$-\cdot948$	$-\cdot037$	$-\cdot006$	$-\cdot007$	
46	x_E		$+1\cdot745$	$-\cdot964$	$-\cdot008$	$+\cdot023$	$+\cdot024$	$\frac{1}{2}$
47	x_E		$+1\cdot754$	$-1\cdot030$	$-\cdot010$	$+\cdot023$	$+\cdot024$	
48		x_W	$+1\cdot754$	$-1\cdot035$	$-\cdot003$	$+\cdot030$	$+\cdot029$	
49	x_E		$+1\cdot759$	$-1\cdot073$	$-\cdot029$	$+\cdot005$	$+\cdot006$	
50		x_W	$+1\cdot760$	$-1\cdot078$	$-\cdot078$	$-\cdot044$	$-\cdot045$	
51		x_W	$+1\cdot779$	$-1\cdot216$	$-\cdot028$	$+\cdot009$	$+\cdot008$	
52		x_W	$+1\cdot784$	$-1\cdot254$	$-\cdot049$	$-\cdot011$	$-\cdot012$	

Combining both series, and giving half weight to the equations which depend on "half sets" of observations, the following normals are obtained:—

$$
\begin{array}{rrrrr}
19\cdot500x_E & & +23\cdot292y & +9\cdot837\pi & =+0\cdot146 \\
 & 27\cdot000x_W & +20\cdot605 & -35\cdot371 & -\cdot714 \\
23\cdot292 & +20\cdot605 & +68\cdot512 & -22\cdot938 & -\cdot837 \\
9\cdot837 & -35\cdot371 & -22\cdot938 & +83\cdot062 & +1\cdot816
\end{array}
$$

If we assume that the measures are free from systematic error, that is write $x=x_E=x_W$, we obtain, from the solution of these normals and the

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substitution of the values of the unknowns in the original equations, the following results:—

$$[p.vv] = 0\cdot0109 \qquad \epsilon^2 = 0\cdot000222$$

$x = +0\cdot0112$,	Weight 16·8,	Probable error $\pm 0\cdot0025$
y $-$ ·0121	„ 26·9	„ ·0019
π $+$ ·0220	„ 69·0	„ ·0012

or

$$\pi = 0''\cdot283 \pm 0''\cdot0156$$

and the probable error of an observation

$$= \pm 0\cdot01006 = \pm 0''\cdot129$$

The representation of this solution is given in Column I. beside the equations.

If, on the other hand, we solve the normals as they stand, and substitute the values of the unknowns in the original equations, we obtain

$$[p.vv] = 0\cdot0110 \qquad \epsilon^2 = 0\cdot000229$$

x_E $+0\cdot0102$,	Weight 7·4,	Probable error $\pm 0\cdot0038$
x_W + ·0121	„ 10·0	„ ·0032
y $-$ ·0118	„ 23·1	„ ·0021
π $+$ ·0225	„ 29·4	„ ·0018

or

$$\pi = 0''\cdot289 \pm 0''\cdot024$$

and the probable error of one observation is

$$\pm 0\cdot0102 = \pm 0''\cdot131$$

The representation of this solution (almost identical with the former) is given in Column II. adjoining the equations.

The evidence of this second solution, like that of the previous solution, tends to show that, in reality, there is no systematic error in these observations. The introduction of an additional unknown to represent such error, increases the probable error of an observation, and in both solutions the value of $(x_E - x_W)$ is far within the probable error of its determination.

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It is practically of no consequence which of the solutions we adopt, but we cannot be far wrong in adopting as the results of this investigation

$$\pi = 0''.285 \pm 0''.02$$

as the parallax of the star *Lacaille* 9352 with reference to the comparison stars employed.

§ 10. *Parallax of* o_2 *Eridani.* GILL.

This is the principal star of one of the most remarkable systems in the heavens. A (o_2 *Eridani*) 4·4 magnitude (GOULD), has, according to MAIN, a proper motion of 4″·10 on the great circle; a companion double star B and C, 9½ and 10½ mag. respectively, distant from A 82″, partakes of the large proper motion of A.

OTTO STRUVE (*Obs. de Poulkova*, vol. ix. p. 38) gives the following measures of B relative to A.

Epoch.	*s.*	*p.*	No. of Days.	Observer.
1825·05	85″·325	107° 29′	2	Σ.
36·04	83·482	107 16	4	Σ.
51·22	82·245	106 10	4	O.Σ.
55·06	81·013	105 58	6	O.Σ.
65·37	81·641	105 42	4	O.Σ. and WINNECKE
71·13	81·910	105 53	3	O.Σ.

There appears some evidence of a minimum in position angle and distance about 1865, though this conclusion would require the confirmation of further measures. But when the enormous proper motion common to both stars is considered, we can no longer doubt their physical connection, nor the reality of their rotation about a common centre of gravity. A binary star, of which the apparent distance of the components amounts to 82″, might reasonably be expected to have a sensible parallax, and this expectation is greatly heightened by the excessive proper motion. But the interest in the system is still further heightened by the fact that the double star BC is proved by the

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following measures (*Obs. de Poulkova*, vol. ix. p. 38) to be beyond doubt binary.

Epoch.	*s.*	*p.*	No. of Days.	Observers.
	"	°		
1783·13		326·7	1	W. Herschel.
1825·12		287	1	Σ.
51·22	3·915	155·85	4	O.Σ.
55·06	4·138	154·02	6	O.Σ.
66·12	4·380	144·70	5	O.Σ. and Wilnecke.
73·85	4·270	136·98	4	O.Σ.

Otto Struve, from these measures, estimates the period of revolution of B and C at less than two hundred years.

The only favourable comparison stars are *Lalande* 7819 and 8154 of 6·0 and 6·7 magnitude (Gould) respectively, but they are fortunately well situated for my purpose.

The results of Meridian observations of these stars, reduced to the Equinox of 1882·0, without any corrections for proper motion, are—

Authority.	1882·0.		Epoch.	No. of Obs.
	α	*δ*		
		α.		
	h m s	° ′ ″		
Lalande	4 5 6·51	−9 7 41·1	1796·7	
Paris	4 5 6·73	−9 7 42·0	1860·5	
Cordoba	4 5 6·84	−9 7 42·3	1876·96	4
Cape	4 5 6·75	−9 7 42·0	1883·26	3
		β.		
Lalande	4 14 50·32	−6 31 33·2	1797·8	
Paris	4 14 51·22	−6 31 40·1	1876·5	
Cordoba	4 14 51·26	−6 31 39·0	1879·98	3
Cape	4 14 51·47	−6 31 38·8	1882·07	3

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The proper motions are obviously very small.

The proper motion of o_2 *Eridani* is with close approximation to truth—

$$\text{in R.A. } -0^{s}\cdot148, \qquad \text{in Dec. } -3''\cdot46.$$

The position angles and distances of the comparison stars relative to o_2 *Eridani*, which have been employed in the reductions, are—

	p	s
	°	R
o_2 *Eridani*–α	220·17	487·3
o_2 *Eridani*–β	43·52	505·2
Difference	183·35	17·9

The above adopted proper motions in R.A. and Declination are equivalent to a motion of $4''\cdot102$ in the direction $p=212°\cdot45$—that is, nearly in the line of the measured distances. The projection of this motion on the line o_2 *Eridani*-α and o_2 *Eridani*-β gives the following values of the annual variations of these distances:—

	$\frac{\Delta s}{\Delta t}$
	R
o_2 *Eridani*–α	−0·3144
o_2 *Eridani*–β	+ ·3130

The parallax factors are—

For distance of o_2 *Eridani* from α ... ... 0·8575 R cos ($\odot - 129°\cdot76$)

„ „ „ β ... ... ·8675 R cos ($\odot - 310°\cdot63$)

and for

β–α ... ... 1·725 R cos ($\odot - 310°\cdot2$)

Whence the maximum and minimum effect of parallax on $\beta-\alpha$ occur the 30th January and the 2nd August respectively.

The corrections for aberration have been computed, as in the previous sections of my work; the constants are—

	Star α.	Star β.
log. a	+7·2837	+7·3116
b	−7·0421	−7·0414

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The observations have been confined to epochs near the maximum and minimum of parallax, as it was not possible, with the other work in hand, to carry out the observations during the whole course of the year. I had intended, however, before closing my work, to make a series of observations both East and West of the Meridian about the time when o_2 *Eridani* culminates near midnight. But the results of the discussions of my observations of *Sirius*, ϵ *Indi*, and specially of *Lacaille* 9352, seemed to show that no suspicion of systematic error could attach to observations of stars so easy and so symmetrical as those now in question, and thus I did not consider such observations to be necessary.

The screen employed was a single fold of wire gauze (the same as that used by ELKIN in his observations of ϵ *Indi*) which reduced the brilliancy of o_2 *Eridani* to about that of a star of $6\frac{1}{2}$ magnitude—*i.e.* to brightness about midway between that of the stars of comparison. The observations consist of four groups, about the epochs of minimum parallax in the latter part of July 1881 and 1882, and about the maximum of parallax in January and February 1882 and 1883. In the first of these groups I have been compelled to admit observations made in worse circumstances of steadiness of the air than is denoted by the figure 3. The images were generally good, but as the stars are then nearly vertical, the altitude rather small, and the distances rather great (over 6400″ each), the conditions combine to increase the relative unsteadiness of the images. The observations are given in the following Table, corrected as usual for refraction, aberration, and proper motion.

The effect of any parallax of o_2 *Eridani* on the sums of the distances is quite insensible.

The mean sum of distances (S_0) is $992^R{\cdot}4965$, and their mean difference (D_0) is $17^R{\cdot}8950$; the correction, ΔD, of the difference $\beta-\alpha$ to reduce it to normal scale value is—

$$\Delta D = 0{\cdot}018\ (S_0 - S)$$

a quantity which has been applied, although in one case only (No. 9) does it amount to so much as $0^R{\cdot}002$.

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Observations.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	α	β	$\beta-\alpha+\Delta D$
	1881.	h m			°	R	R	R
1	July 11	0 30	2–3	3–4	48·0	487·3351	505·2353	17·8989
2	15	0 52*			42·7	·3482	·2244	·8748
3	19	0 55†			37·5	·3600	·2374	·8756
4	25	1 9	2	3	53·5	·3091	·1654	·8567
5	26	1 19	2–3	3–4	43·0	·3374	·1655	·8281
6	28	1 15	2	3–4	48·4	·2727	·1558	·8843
	1882.							
7	Jan. 4	6 34	2	3–4	63·3	·2765	·1892	·9133
8	7	7 59	2–3	3	60·0	·2898	·1673	·8782 ½ set
9	10	7 8	1–2	2	60·5	·2282	·1428	·9169
10	23	6 30‡			64·5	·2697	·2048	·9355
11	24	6 33			60·5	·2910	·2145	·9234 ½ set
12	Feb. 3	6 27	2–3	3	65·3	·2909	·1967	·9059 ½ set
13	6	6 57	3	3	68·0	·2488	·1909	·9431
14	14	6 34	1–2	2–3	67·0	·2603	·1713	·9121
15	July 9	1 5	1–2	2–3	40·5	·3209	·2152	·8936
16	11	0 50	1	2	48·0	·3024	·1692	·8672 ½ set
17	13	1 8‡			40·0	·3017	·2061	·9042
18	22	1 32	2	3	49·3	·3148	·1773	·8626
19	26	1 24	2–3	3	51·5	·3432	·2064	·8622
20	27	1 31	1–2	2	45·5	·3218	·2076	·8852
21	30	1 13	1–2	2	54·0	·3196	·1850	·8653
22	Aug. 16	1 16	2–3	3	49·0	·3108	·1683	·8578 ½ set
	1883.							
23	Feb. 6	8 11	3	3	65·8	·3509	·1936§	[·8418] ½ set
24	10	8 5	2–3	2–3	66·5	·2869	·2215	·9344
25	11	7 51	2	2–3	66·8	·3018	·2075	·9055
26	13	7 10	1–2	2–3	63·8	·2921	·1944	·9025
27	14	7 12	2	2–3	64·0	·2880	·2364	·9479
28	15	7 6	2–3	2–3	62·8	·3013	·2242	·9224 ½ set
29	18	7 44	3	3	77·8	·2886	·2174	·9287
30	19	7 31	2–3	2–3	72 8	·2703	·2068	·9368

These observations lead to the following equations of condition, in which $(\beta-\alpha+\Delta D)$ is assumed $= 17^{R}\cdot895+x$.

* The agreement of the separate observations appears to indicate fairly good definition.

† The observations of α *Centauri* with stars α and β, made 6^{h} before, are marked "Images 1–2," "Steadiness 2–3;" the conditions are probably similar.

‡ The agreement of separate observations is very satisfactory; definition probably good.

§ Pivot of screen axis broken; half set made without screen, of no use.

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Equations of Condition.

No.										v	p
1	x	−	0·48y	−	0·95z	= +	0·004			+ ·030	½
2	x	−	·47	−	·97	−	·020			+ ·006	
3	x	−	·45	−	·99	−	·019			+ ·007	
4	x	−	·44	−	1·01	−	·038			− ·011	
5	x	−	·43	−	1·01	−	·067			− ·041	½
6	x	−	·43	−	1·01	−	·011			+ ·015	½
7	x	+	·01	+	0·89	+	·018			− ·002	½
8	x	+	·02	+	·91	−	·017			− ·037	½
9	x	+	·03	+	·93	+	·022			+ ·001	
10	x	+	·06	+	·98	+	·040			+ ·018	
11	x	+	·06	+	·98	+	·028			+ ·006	½
12	x	+	·09	+	·98	+	·011			− ·012	½
13	x	+	·10	+	·98	+	·048			+ ·025	½
14	x	+	·12	+	·95	+	·017			− ·005	
15	x	+	·52	−	·94	−	·001			+ ·015	
16	x	+	·53	−	·95	−	·028			− ·012	½
17	x	+	·53	−	·96	+	·009			+ ·026	
18	x	+	·56	−	1·00	−	·022			− ·005	
19	x	+	·57	−	1·01	−	·033			− ·016	
20	x	+	·57	−	1·01	−	·010			+ ·007	
21	x	+	·58	−	1·01	−	·030			− ·013	
22	x	+	·62	−	0·98	−	·037			− ·021	½
24	x	+	1·11	+	·97	+	·039			+ ·007	
25	x	+	1·11	+	·96	+	·011			− ·021	
26	x	+	1·12	+	·96	+	·008			− ·024	
27	x	+	1·12	+	·95	+	·053			+ ·022	
28	x	+	1·12	+	·95	+	·027			− ·004	½
29	x	+	1·13	+	·93	+	·034			+ ·003	½
30	x	+	1·14	+	·92	+	·042			+ ·011	

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In forming normals weights have been assigned to the equations as follows:—

To equations 8, 11, 12, 16, 22, 28; $\frac{1}{2}$ weight, because they depend upon "half sets" of observations.

„ 1, 5, 6, 7, 13, 29; $\frac{1}{2}$ weight, because they depend on observations made with *Images* 3, or *Steadiness* 3-4.

All the other equations have received weight 1.

The resulting normals are—

$$\begin{array}{rrrr} 23{\cdot}00x & + 8{\cdot}95y & - 0{\cdot}42z & = {}^{R}+0{\cdot}073 \\ 8{\cdot}95 & +10{\cdot}67 & + 4{\cdot}88 & + {\cdot}206 \\ - 0{\cdot}42 & + 4{\cdot}88 & +21{\cdot}61 & + {\cdot}526 \end{array}$$

and their solution, with the substitution of the values of the unknowns in the equations of condition, leads to the following results :—

$$[pvv] = 0{\cdot}006005, \qquad \varepsilon^2 = 0{\cdot}000231$$

$x = {}^{R}+0{\cdot}00005$,	Weight 14·44,	Probable error $\pm {}^{R}0{\cdot}0027$	
y + ·0091	„ 6·01	„ ·0042	
z + ·0223	„ 18·06	„ ·0024	

whence the probable error of one observation is

$$\pm {}^{R}0{\cdot}01025 = \pm 0''{\cdot}132$$

and

$$\pi = 0''{\cdot}166 \pm 0''{\cdot}018.$$

The residuals from this solution are given beside the equations.

The following are the mean values of the squares of the residuals multiplied by the weight for each class of observation :

Observations that have received weight *unity*	$^{R}0{\cdot}000213$
„ depending on "half sets"	·000179
„ "Images 3" or "Steadiness 3 or 4" ...	·000217

It is therefore quite unnecessary to rediscuss the equations with modified weights.

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From what has already been shown by my preceding researches of the probable freedom of such measures from systematic error, I think that the above determined value of the parallax of o_2 *Eridani* relative to these comparison stars may be accepted with considerable confidence.

§ 11. *Parallax of β Centauri.* GILL.

The Meridian observations of MACLEAR appear to show that this star has considerable parallax.* It is of great interest to test this result, because it bears on the important question of the reliability of Meridian observations in such delicate inquiries.

There is unfortunately no symmetrically situated pair of stars suitable for determining the parallax of *β Centauri* which, at the same time, is also bright enough for observations with my heliometer. But there is near *β Centauri* a star (γ) of 7th magnitude (Plate I., fig. 6), which is very favourably situated for parallax factor in measures of distance. It is inconsistent with the principles laid down in the Introduction to employ any method which depends on our knowledge of the absolute instantaneous scale-value, and therefore it was necessary to devise some independent method of determining the absolute scale-value at the time of each observation of *β Centauri*. The programme of observation could not be increased without risk of ultimate failure, and it appeared sufficient to observe *β Centauri* immediately before or immediately after observations of *α Centauri* with the stars *α* and *β*, taking care to make such observations alternately before and after those of *α Centauri*.

Thus the standard of scale-value in the present investigation is the observed sum of the distances α_2 *Centauri-α* and α_2 *Centauri-β*, of which the mean observed sum (S_0) is $=536^{R}\cdot051$. To obtain the correction for abnormal scale-value in observations of *β Centauri* it is only necessary to multiply the corresponding values of $(S_0 - S)$ in §1 by

$$\frac{\text{Mean distance of } \beta \text{ Centauri from comparison star } \gamma}{S_0}$$

that is, by

$$0\cdot138\ (S_0 - S)$$

* See *Elkin's Dissertation* before referred to, p. 6; also *Mem. R.A.S.*, vol. xxi., p. 141.

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The separate values of $S_o - S$ with the corresponding corrections to the observations of β *Centauri* are given in the following Table of Observations.

The Meridian observations of the comparison star γ are the following, reduced to 1882·0 without proper motion; a correction of $+2^s\cdot2$ being applied to the R.A. from Brisbane's *Catalogue* (see p. 273 of that work):—

Authority.	Epoch.	1882·0.		No. of Obs.
		α	δ	
		h m s	° ′ ″	
Brisbane	1825	13 53 38·42	−59 41 2·3	
Cordoba	1878·45	37·97	5·5	4
Cape	1882·53	37·90	5·2	9

The position angle and distance of the star γ from β *Centauri* have been taken—

$$p = 296^\circ\ 26'\qquad s = 73''\cdot920$$

The parallax factor of β *Centauri* for measures of distance from the star γ is—

$$0\cdot9995\,R\cos(\odot - 320^\circ\cdot4)$$

it is therefore almost the most favourable possible; the maximum distance on account of parallax should occur on February 9 and the minimum on August 13.

The small proper motion of β *Centauri* takes place nearly at right angles to the line of measurement, and no correction has been applied to the observations on account of proper motion.

The aberration constants, employed as in my previous papers, are—

$$\log. a\ -6\cdot3440$$
$$\log. b\ +6\cdot1999$$

The following Table contains the results of the observations. Each "set" is in this case the mean of four bisections only—that is, of two observations made in reversed positions of the position circle.

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No.	Date.	Sidereal Time.	Definition.		Temperature.	S_0–S.	Correction for Scale Value.	Corrected Observation.
			I.	S.				
	1881.	h m			°	R		R
1	July 11	16 40	1–2	1–2	59·0	−·035	−·0048	73·9172
2	12	18 55	—	—	41·0	−·052	−·0072	·9273
3	19	16 49	1–2	1–2	42·0	−·028	−·0039	·9058
4	Aug. 30	18 28	—	—	55·0	+·058	+·0080	·8924
5	Sept. 3	18 51	1	2	47·0	+·038	+·0052	·9167
6	7	19 17	3	3	55·0	+·011	+·0015	·9237
	1882.							
7	Jan. 11	11 19	1–2	1–2	62·5	+·067	+·0092	·9162
8	18	11 36	1–2	1–2	61·5	+·022	+·0030	·9273
9	28	9 53	2	2	67·0	−·040	−·0055	·9201
10	Feb. 10	7 28	3–4	3–4	68·5	+·010	+·0014	[·9177]
11	13	8 6	3	3	70·5	+·013	+·0018	·9286
12	22	8 29	2	2	54·5	−·007	−·0010	·9136
13	23	10 42	2–3	2–3	66·0	+·031	+·0042	·9198
14	Mar. 5	8 18	2	2	65·0	+·036	+·0050	·9273
15	6	12 21	1–2	1–2	55·0	+·018	+·0025	·9048
16	9	8 39	2	2	61·0	+·056	+·0077	·9099
17	11	8 56	2–3	3	63·0	+·049	+·0068	·9159
18	14	8 23	2	2–3	62·0	+·029	+·0040	·9139
19	14	10 7	1	1–2	65·0	+·029	+·0040	·9169
20	23	10 16	2	2	64·0	+·061	+·0084	·9108
21	31	9 44	1–2	1–2	64·0	+·049	+·0068	·9167
22	April 2	9 31	—	—	63·0	+·013	+·0018	·9061
23	7	19 4	2	2	62·0	+·021	+·0030	·9454
24	8	11 5	1–2	1–2	56·5	+·024	+·0033	·9222
25	11	10 29	1	2	58·3	+·064	+·0088	·9194
26	25	12 32	—	—	58·0	+·036	+·0050	·9120
27	28	11 20	1	1	59·0	+·057	+·0079	·9161
28	May 9	10 46	1	1	56·0	+·061	+·0084	·9301
29	26	11 12	2	2	59·0	+·093	+·0128	·9130
30	26	16 52	2	2–3	60·0	+·059	+·0081	·9298
31	July 11	17 14	2–3	2–3	52·0	+·035	+·0048	·9107
32	27	16 48	2–3	2–3	52·0	−·019	−·0026	·9274
33	31	20 31	2	2	55·5	+·077	+·0106	[·9679]
34	Aug. 1	16 32	2	2	57·0	·000	·0000	·9096
35	4	17 9	2–3	2–3	56·0	+·002	+·0003	·9300
36	18	19 6	—	—	48·0	−·006	−·0008	·9265
37	19	19 19	2–3	2–3	50·0	−·004	−·0005	·9452

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No.	Date.	Sidereal Time.	Definition.		Temperature.	S_0-S.	Correction for Scale Value.	Corrected Observation.
			I.	S.				
	1882.	h m			°	R		R
38	Aug. 21	18 29	2	2–3	54·0	+·009	+·0012	73·9344
39	23	18 42	2	2	50·0	+·007	+·0010	·9242
	1883.							
40	Feb. 11	9 11	—	—	63·0	−·042	−·0058	·9230
41	18	9 33	2–3	2	72·0	−·054	−·0074	·9183
42	Mar. 8	12 21	3	3	60·0	−·070	−·0097	·9110

Taking the true mean distance for $1882{\cdot}0 = 73{\cdot}920 + x$ these observations lead to the following equations of condition:—

Equations of Condition.

No.					I.	II.
1	$1{\cdot}00x$	$-0{\cdot}48y$	$-0{\cdot}87\pi$	$=-0{\cdot}003$	$-0{\cdot}002$	$+{\cdot}010$
2	$1{\cdot}00$	$-{\cdot}47$	$-{\cdot}91$	$+{\cdot}007$	$+{\cdot}008$	$+{\cdot}006$
3	$1{\cdot}00$	$-{\cdot}45$	$-{\cdot}93$	$-{\cdot}014$	$-{\cdot}013$	$-{\cdot}008$
4	$1{\cdot}00$	$-{\cdot}34$	$-{\cdot}96$	$-{\cdot}028$	$-{\cdot}027$	$-{\cdot}030$
5	$1{\cdot}00$	$-{\cdot}33$	$-{\cdot}94$	$-{\cdot}003$	$-{\cdot}002$	$-{\cdot}005$
6	$1{\cdot}00$	$-{\cdot}32$	$-{\cdot}92$	$+{\cdot}024$	$+{\cdot}025$	$+{\cdot}022$
7	$1{\cdot}00$	$+{\cdot}03$	$+{\cdot}86$	$-{\cdot}004$	$-{\cdot}002$	$-{\cdot}002$
8	$1{\cdot}00$	$+{\cdot}05$	$+{\cdot}92$	$+{\cdot}007$	$+{\cdot}009$	$+{\cdot}011$
9	$1{\cdot}00$	$+{\cdot}08$	$+{\cdot}97$	${\cdot}000$	$+{\cdot}002$	$-{\cdot}001$
10	$1{\cdot}00$	$+{\cdot}11$	$+{\cdot}99$	$[-{\cdot}002]$	$[\pm{\cdot}000]$	—
11	$1{\cdot}00$	$+{\cdot}12$	$+{\cdot}98$	$+{\cdot}009$	$+{\cdot}011$	$+{\cdot}013$
12	$1{\cdot}00$	$+{\cdot}14$	$+{\cdot}96$	$-{\cdot}006$	$-{\cdot}004$	$-{\cdot}004$
13	$1{\cdot}00$	$+{\cdot}15$	$+{\cdot}96$	${\cdot}000$	$+{\cdot}002$	$-{\cdot}001$
14	$1{\cdot}00$	$+{\cdot}17$	$+{\cdot}90$	$+{\cdot}007$	$+{\cdot}008$	$+{\cdot}009$
15	$1{\cdot}00$	$+{\cdot}18$	$+{\cdot}89$	$-{\cdot}015$	$-{\cdot}014$	$-{\cdot}005$
16	$1{\cdot}00$	$+{\cdot}18$	$+{\cdot}87$	$-{\cdot}010$	$-{\cdot}009$	$-{\cdot}009$
17	$1{\cdot}00$	$+{\cdot}19$	$+{\cdot}85$	$-{\cdot}004$	$-{\cdot}003$	$-{\cdot}004$
18	$1{\cdot}00$	$+{\cdot}20$	$+{\cdot}83$	$-{\cdot}006$	$-{\cdot}005$	$-{\cdot}004$
19	$1{\cdot}00$	$+{\cdot}20$	$+{\cdot}83$	$-{\cdot}003$	$-{\cdot}002$	$-{\cdot}005$

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Equations of Condition—continued.

No.				I.	II.
20	1·00x	+0·22y	+0·73π = −0·009	−0·008	− ·011
21	1·00	+ ·25	+ ·63 − ·003	− ·002	− ·005
22	1·00	+ ·25	+ ·60 − ·004	− ·003	− ·006
23	1·00	+ ·27	+ ·53 + ·025	+ ·026	+ ·023
24	1·00	+ ·27	+ ·52 + ·002	+ ·003	+ ·002
25	1·00	+ ·28	+ ·48 − ·001	− ·001	− ·003
26	1·00	+ ·31	+ ·26 − ·008	− ·008	+ ·002
27	1·00	+ ·32	+ ·21 − ·004	− ·004	− ·004
28	1·00	+ ·35	+ ·03 + ·010	+ ·010	+ ·007
29	1·00	+ ·40	− ·26 − ·007	− ·008	− ·009
30	1·00	+ ·40	− ·27 + ·010	+ ·009	+ ·013
31	1·00	+ ·52	− ·87 − ·009	− ·011	− ·010
32	1·00	+ ·57	− ·98 + ·007	+ ·005	+ ·008
33	1·00	+ ·58	− ·99 [+ ·048]		
34	1·00	+ ·58	−1·00 − ·010	− ·013	− ·007
35	1·00	+ ·59	−1·00 + ·010	+ ·007	+ ·008
36	1·00	+ ·63	−1·01 + ·007	+ ·004	+ ·001
37	1·00	+ ·63	−1·01 + ·025	+ ·022	+ ·019
38	1·00	+ ·64	−1·00 + ·014	+ ·011	+ ·008
39	1·00	+ ·64	−0·99 + ·004	+ ·001	− ·002
40	1·00	+1·11	+ ·99 + ·002	·000	− ·005
41	1·00	+1·13	+ ·98 − ·002	− ·004	− ·010
42	1·00	+1·18	+ ·88 − ·009	− ·007	− ·006

In forming normals the equation 10, which depends on observations made with Images 3–4, has, as usual, been rejected. I have also rejected one very discordant observation, No. 33, as it was made at an exceptionally great hour angle.

The resulting normals are—

$$\begin{array}{llll} +40{\cdot}00x & +10{\cdot}84y & -\ 1{\cdot}96\pi & = +0{\cdot}008 \\ +10{\cdot}84 & +\ 9{\cdot}09 & -\ 3{\cdot}43 & +\ {\cdot}027 \\ -\ 1{\cdot}96 & -\ 3{\cdot}43 & +27{\cdot}67 & -\ {\cdot}046 \end{array}$$

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their solution, and the substitution of the values of the unknowns in the original equations, lead to the following results:—

$$[vv] = 0{\cdot}004343 \qquad \varepsilon^2 = 0{\cdot}000127$$

$x = -0{\cdot}0008^{R}$,	Weight 26·90,	Probable error $\pm 0{\cdot}0015^{R}$	
y + ·0034	„ 5·85	„	·0030
π − ·0013	„ 26·21	„	·0014

Hence the probable error of one observation is

$$\pm 0{\cdot}0073^{R} = \pm 0{\cdot}094''$$

and

$$\pi = 0{\cdot}017'' \pm 0{\cdot}018''$$

The negative parallax, with a probable error greater than its amount, simply proves that the difference of parallax between β *Centauri* and its comparison star is probably not greater than 0″·02, unless the result is affected by some systematic error.

In making the observations the same screen was used as that employed in the case of α *Centauri*, and the Image of β *Centauri*, when viewed through this screen, was apparently identical in colour and magnitude with that of the comparison star γ. In such circumstances it is impossible to imagine any kind of error that will not be identical for $(p-q)$ and $180^\circ+(p-q)$.

Therefore, to determine whether the resulting parallax might be affected by errors depending on $p-q$, it is only necessary to substitute for x in the original equations—

$$x+\cos 2\,(p-q)\,\alpha+\sin 2\,(p-q)\,\beta$$

The equations of condition, so formed, lead to the following normals:—

$$\begin{array}{rrrrrr}
+40{\cdot}00x & +22{\cdot}10\alpha & -21{\cdot}79\beta & +10{\cdot}84y & -\ 1{\cdot}96\pi & = +0{\cdot}008 \\
+22{\cdot}10 & +18{\cdot}44 & +\ 7{\cdot}23 & +\ 6{\cdot}21 & +\ 1{\cdot}93 & +\ {\cdot}029 \\
+21{\cdot}79 & +\ 7{\cdot}23 & +21{\cdot}66 & +\ 5{\cdot}03 & -\ 4{\cdot}39 & +\ {\cdot}033 \\
+10{\cdot}84 & +\ 6{\cdot}21 & +\ 5{\cdot}03 & +\ 9{\cdot}09 & -\ 3{\cdot}43 & +\ {\cdot}029 \\
-\ 1{\cdot}96 & +\ 1{\cdot}93 & -\ 4{\cdot}39 & -\ 3{\cdot}43 & +27{\cdot}67 & -\ {\cdot}046
\end{array}$$

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The solution of these normals and the substitution of the values of the unknowns in the original equations lead to the following results:—

x	$= -0''.01125$	$[vv] = 0''.004076$
a	$+ .01072$	
β	$+ .00798$	$\epsilon^2 = 0''.000117$
y	$+ .00412$	
π	$- .00144,$	Weight 24·34

The representation of this solution is given in Column II. beside the original equations of condition ; and we have—

$$\pi = -0''.018 \pm 0''.019$$

and the probable error of one observation is—

$$\pm 0''.0073 = \pm 0''.094$$

There is thus no evidence of any systematic error depending on the angle which the direction of measurement makes with the vertical, and the conclusion appears to be well founded that the parallax of *β Centauri* is very small.

Unless we accept the very improbable assumption that the comparison star γ, of 7th magnitude, has an annual parallax of about $0''.3$, it appears quite certain that the values of the parallax of *β Centauri*, derived by Henderson, Maclear, and Moesta, are chiefly due to systematic errors which are not easily eliminated from observations of absolute altitude.

§ 12. *Parallax of ζ Tucanæ.* Elkin.

The approximate positions of the two comparison stars I selected for *ζ Tucanæ*, a star with an annual proper motion over $2''$, are as follows:—

Star.	Magnitude.	Distance.	Position Angle.
		R	° ′
a	$7\frac{1}{2}$	403·7	355 1
b	$7\frac{1}{2}$	393·5	171 25
	Difference ...	10·2	183 36

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The factor of parallax for the *difference* of the distances ζ *Tucanæ-a*—ζ *Tucanæ-b* is

$$+1\cdot830 \sin (\odot + 263^\circ\cdot4)\,.\,\mathrm{R},$$

so that on the whole the pair must be considered a very favourable one. The observations do not extend continuously over the whole period embraced by them, but it will be found that there are a number which fall between the maxima of parallax, and may serve to test the freedom of the series from systematic error.

The results are given in the usual form in the following Table. The aberration corrections are—

$$\begin{array}{lll} \zeta \text{ Tucanæ } a & \ldots \quad \ldots & {}^{\mathrm{R}}_{} +0\cdot0217 \sin (\odot + 218^\circ\cdot6) \\ \text{,, } b & \ldots \quad \ldots & +0\cdot0206 \sin (\odot + 220^\circ\cdot4) \end{array}$$

and the proper motions have been taken for

$$\begin{array}{lll} \zeta \text{ Tucanæ } a & \ldots \quad \ldots & {}^{\mathrm{R}}_{} -0\cdot0785 \\ \text{,, } b & \ldots \quad \ldots & +0\cdot0696 \end{array}$$

the annual motions of ζ *Tucanæ* being assumed

$$^{\mathrm{s}}_{} +0\cdot273 \text{ and } +1''\cdot16$$

which represent the Meridian observations as follows:—

Authority.	R.A. 1880·0.	Decl. 1880·0.	Observations.
	h m s	° ′ ″	
Johnson, 1830	0 13 48·69	−65 34 48·9	7,7
Cape, 1840	48·83	49·1	9,5
Cape, 1860	48·45	48·8	3,3
Melbourne, 1870	48·53	47·6	3,3
Cordoba, 1874	48·58	48·2	7,6
Cape, 1880	48·60	49·0	3,3
Cordoba, 1880	48·27	48·1	3,3

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Observations.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	ζ *Tucanæ-a*	ζ *Tucanæ-b.*
	1881.	h m			°	R	R
1	Mar. 11	8 1	2	2–3	70·4	403·714	393·544
2	12	7 41	3	3	65·4	·659	·477
3	April 12	18 32	2–3	3	56·9	·629	·463
4	20	18 48	3	3	53·0	·720	·559
5	22	19 2	2–3	3	50·6	·707	·549
6	May 6	20 28	3	3	50·1	·713	·549
7	June 20	21 53	2–3	3	55·1	·652	·488
8	July 4	18 11	2	2–3	50·9	·704	·539
9	5	19 48	2	2–3	43·2	·706	·527
10	11	19 38	2	2	48·4	·683	·494
11	Aug. 28	20 25	3	3	49·0	·679	·467
12	Sept. 5	23 13	2	2	47·2	·663	·478
13	6	21 56	1–2	1–2	43·2	·655	·474
14	8	21 52	3	3	66·5	·629	·462
15	14	22 13	2	2	52·7	·645	·476
16	20	22 28	1–2	2	56·0	·657	·501 ¾ set
17	25	21 37	1–2	2	55·7	·694	·534
18	26	23 0	1–2	1–2	50·3	·666	·470 ¾ set
19	Oct. 10	22 31	1–2	2	50·3	·694	·533
20	Dec. 10	5 22	2–3	2–3	61·2	·678	·511
21	13	4 35	2–3	3	61·0	·705	·510
	1882.						
22	Jan. 23	4 59	2–3	3	65·0	·668	·478
23	Mar. 5	6 59	2	2–3	66·0	·646	·461
24	14	7 20	2–3	3	61·5	·636	·479
25	20	7 34	2	2–3	64·2	·640	·512
26	April 2	17 27	2–3	2–3	62·0	·648	·490
27	18	19 20	2–3	2–3	57·5	·624	·496
28	May 4	20 23	2–3	2–3	57·7	·636	·467

The equations of condition have been deduced as usual; the differences have been corrected by the formula

$$-(\text{Obs. Difference} - {}^{R}797{\cdot}170)\ \frac{10{\cdot}17}{797{\cdot}17}$$

and x denotes the correction to the assumed mean difference ζ *Tucanæ-a* − ζ *Tucanæ-b*

$$^{R}10{\cdot}170$$

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Equations of Condition.

No.		Residuals.		Pos.
	R	R	R	
1	$+1{\cdot}0x-0{\cdot}959y-0{\cdot}806z=-0{\cdot}0010$	$+0{\cdot}001$	$-0{\cdot}004$	W
2	$1{\cdot}0-{\cdot}963-{\cdot}804+{\cdot}0120$	$+{\cdot}014$	$+{\cdot}009$	W
3	$1{\cdot}0-{\cdot}958-{\cdot}718-{\cdot}0024$	$+{\cdot}001$	$+{\cdot}005$	E
4	$1{\cdot}0-{\cdot}915-{\cdot}696-{\cdot}0097$	$-{\cdot}007$	$-{\cdot}003$	E
5	$1{\cdot}0-{\cdot}900-{\cdot}690-{\cdot}0134$	$-{\cdot}010$	$-{\cdot}007$	E
6	$1{\cdot}0-{\cdot}773-{\cdot}652-{\cdot}0076$	$-{\cdot}005$	$-{\cdot}003$	E
7	$1{\cdot}0-{\cdot}121-{\cdot}529-{\cdot}0049$	$-{\cdot}007$	$+{\cdot}011$	E′
8	$1{\cdot}0+{\cdot}114-{\cdot}491-{\cdot}0059$	$-{\cdot}010$	$-{\cdot}017$	E
9	$1{\cdot}0+{\cdot}129-{\cdot}488+{\cdot}0077$	$+{\cdot}004$	$-{\cdot}004$	E
10	$1{\cdot}0+{\cdot}231-{\cdot}472+{\cdot}0198$	$+{\cdot}015$	$+{\cdot}007$	E
11	$1{\cdot}0+{\cdot}866-{\cdot}341+{\cdot}0424$	$+{\cdot}034$	$+{\cdot}019$	E
12	$1{\cdot}0+{\cdot}917-{\cdot}319+{\cdot}0154$	$+{\cdot}007$	$+{\cdot}011$	E″
13	$1{\cdot}0+{\cdot}931-{\cdot}316+{\cdot}0119$	$+{\cdot}003$	$+{\cdot}010$	E′
14	$1{\cdot}0+{\cdot}944-{\cdot}311-{\cdot}0022$	$-{\cdot}011$	$-{\cdot}004$	E′
15	$1{\cdot}0+{\cdot}973-{\cdot}294-{\cdot}0012$	$-{\cdot}010$	$-{\cdot}005$	E′
16	$1{\cdot}0+{\cdot}993-{\cdot}278-{\cdot}0141$	$-{\cdot}023$	$-{\cdot}018$	E″
17	$1{\cdot}0+1{\cdot}000-{\cdot}264-{\cdot}0117$	$-{\cdot}020$	$-{\cdot}014$	E′
18	$1{\cdot}0+1{\cdot}001-{\cdot}261+{\cdot}0265$	$+{\cdot}018$	$+{\cdot}022$	E″
19	$1{\cdot}0+0{\cdot}980-{\cdot}223-{\cdot}0097$	$-{\cdot}018$	$-{\cdot}014$	E″
20	$1{\cdot}0+{\cdot}297-{\cdot}056-{\cdot}0031$	$-{\cdot}005$	$-{\cdot}021$	W
21	$1{\cdot}0+{\cdot}246-{\cdot}048+{\cdot}0252$	$+{\cdot}025$	$+{\cdot}008$	W
22	$1{\cdot}0-{\cdot}453+{\cdot}065+{\cdot}0202$	$+{\cdot}026$	$+{\cdot}018$	W
23	$1{\cdot}0-{\cdot}922+{\cdot}176+{\cdot}0154$	$+{\cdot}026$	$+{\cdot}024$	W
24	$1{\cdot}0-{\cdot}971+{\cdot}201-{\cdot}0125$	$-{\cdot}001$	$-{\cdot}003$	W
25	$1{\cdot}0-{\cdot}991+{\cdot}217-{\cdot}0420$	$-{\cdot}030$	$-{\cdot}031$	W
26	$1{\cdot}0-{\cdot}994+{\cdot}254-{\cdot}0115$	$+{\cdot}001$	$+{\cdot}009$	E
27	$1{\cdot}0-{\cdot}930+{\cdot}298-{\cdot}0411$	$-{\cdot}029$	$-{\cdot}021$	E
28	$1{\cdot}0-{\cdot}783+{\cdot}341\quad{\cdot}0000$	$+{\cdot}011$	$+{\cdot}018$	E

Forming the normals with equal weights for all observations leads to the following results:—

$$\begin{array}{llll} +28{\cdot}00x & -2{\cdot}01y & -7{\cdot}50z & =+0{\cdot}002 \\ -2{\cdot}01 & +18{\cdot}97 & -0{\cdot}08 & +{\cdot}159\,[nn]=0{\cdot}00933 \\ -7{\cdot}50 & -0{\cdot}08 & +5{\cdot}34 & -{\cdot}038 \end{array}$$

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$$\begin{array}{lll} & \text{R} & \text{R} \\ z = & -0\cdot0097 & \pm\ 0\cdot0065 \\ y & +\ \cdot0081 & \cdot0027 \\ x & -\ \cdot0020 & \cdot0029 \end{array}$$

$$\pi = 0''\cdot057 \pm 0''\cdot019$$

Probable error, 1 obs. $\pm$ 0·153

The residuals for this solution are placed in Column I. Arranging them according to the qualities of definition I find for the probable error of one observation

	Images.	Observations.	Steadiness.	Observations.
1–2 and 2	$\pm 0''\cdot155$	13	$\pm 0''\cdot145$	8
2–3 and 3	·151	15	·156	20

so that there appears to be no need for weighting the observations.

The resulting values for the proper motion correction and the parallax are not unsatisfactory, the former being not much greater than its probable error; and the latter, small as it is, is three times as large as its probable error, and is fairly well marked by the untouched residuals of the equations of condition.

As regards the possibility of systematic error having crept into this series, it appears to me that there is very little *à priori* likelihood of such having been the case. The screen used reduced ζ *Tucanæ* to so nearly exactly equal brilliancy with the comparison stars, themselves of equal magnitude, that in a slightly illuminated field, such as the light for reading the scale divisions occasioned, it was impossible to distinguish between the two stars under observation, the interference rays caused by the wire gauze being extinguished by the light just mentioned. As, however, the parallax factors run so that the equations can be solved under the assumption of systematic error, without entire loss of weight, I will give the results of such a solution. The case is similar to that of my ϵ *Indi* stars. *East* of the Meridian up to about $21^{h}\cdot9$ Sid. time the stars lie more nearly horizontal than vertical, and afterwards the reverse is the case. Unfortunately, there are a number

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of observations just about $21^{h}\cdot9$ Sid. time for which the position of the head cannot be determined beforehand with certainty, so that I group the observations as follows :—

		h	m		h	m	
Group	E	from 17	27	to	20	28	Sid. time
„	E′	„ 21	37		22	13	„
„	E″	„ 22	28		23	13	„

West of the Meridian, there is no doubt but that one position of the observer's head was used throughout. From this point of view the normals in x take the following form, those in y and z being easily deduced from them and the former ones :—

			R
$+11\cdot00x_{E}$	$-4\cdot91y$	$-3\cdot65z$	$=-0\cdot022$
$+5\cdot00x_{E'}$	$+3\cdot73$	$-1\cdot71$	$-\cdot008$
$+4\cdot00x_{E''}$	$+3\cdot89$	$-1\cdot08$	$+\cdot018$
$+8\cdot00x_{W}$	$-4\cdot72$	$-1\cdot05$	$+\cdot014$

and their solution gives

		R	R
z	$=$	$-0\cdot0131$	$\pm 0\cdot0062$
y		$+\cdot0196$	$\cdot0040$
x_{W}		$+\cdot0116$	$\cdot0046$
$x_{E''}$		$-\cdot0180$	$\cdot0069$
$x_{E'}$		$-\cdot0206$	$\cdot0061$
x_{E}		$+\cdot0024$	$\cdot0043$

$$\pi = 0''\cdot137 \pm 0''\cdot028$$

Probable error, 1 obs. $\pm 0\cdot141$

From the values of $x_{E'}$ and $x_{E''}$ it would appear that these two groups were probably made in the same position of the head, and I have therefore solved the normals assuming $x_{E'}=x_{E''}$. This leads to the values

		R	R
z	$=$	$-0\cdot0131$	$\pm 0\cdot0060$
y		$+\cdot0197$	$\cdot0039$
x_{W}		$+\cdot0116$	$\cdot0045$
$x_{E'}$		$-\cdot0197$	$\cdot0052$
x_{E}		$+\cdot0025$	$\cdot0042$

$$\pi = 0''\cdot138 \pm 0''\cdot027$$

Probable error, 1 obs. $\pm 0\cdot137$

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Solving without the group E′ I get

	R	R
z	$= -0^{R}\cdot0118$	$\pm 0^{R}\cdot0067$
y	$+ \cdot0216$	$\cdot0046$
x_W	$+ \cdot0130$	$\cdot0050$
$x_{E'}$	$- \cdot0197$	$\cdot0075$
x_E	$+ \cdot0037$	$\cdot0047$

$$\pi = 0''\cdot152 \pm 0''\cdot032$$

Probable error, 1 obs. $\pm$ 0·150

which are nearly identical with those of the previous solution, the residuals for which are found in Column II.

These residuals show some slight improvement as compared with Column I., but the value for the parallax is very considerably different from that given by the first solution, and the values for x point to large systematic differences between the several positions—a discouraging result, if admitted to be true, considering the favourable circumstances under which this pair was observed. As before said, however, the conditions of symmetry as regards magnitude and position of the comparison stars and the reduced ζ *Tucanæ* are so completely realised in this series that I can hardly conceive of any instrumental or personal error remaining in the results. Also as regards refraction are the circumstances favourable; on the *East* side of the Meridian, where this last solution points to two values of x differing by $0^{R}\cdot022$ ($=0''\cdot28$), the correction for refraction remains nearly constant, and at its minimum throughout.

Under these circumstances I feel disposed to view these last solutions with distrust, and to throw the apparent discrepancy on to the insufficiency of the observations to bear such a treatment. There are really too few observations to admit of the series being divided up into three or four groups, and it may be readily imagined that an outstanding observation might, under such circumstances, exert an undue influence. That such may have been the case is shown by leaving out in this last solution the two observations which stand out the most—viz., Nos. 12 and 25; the parallax then comes out $= 0''\cdot081 \pm 0''\cdot028$, a result of no particular value, of course, but simply showing what effect a few observations may produce. I am, therefore,

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inclined to consider these latter solutions as merely corroborating the existence of a small relative parallax, and to take as a final result

$$0''.06 \pm 0''.02.$$

This assumes the freedom of the series from systematic error, an assumption which, however, I do not feel to be much hazarded when the facts just mentioned are borne in mind.

§ 13. *Parallax of e Eridani.* ELKIN.

This star, with its large proper motion of over 3″ annually presents also an interesting object for parallax research. The comparison stars employed were by a good deal the brightest of all my pairs, and I only finally selected them because no other pair so symmetrical and equal in magnitude could be found. The approximate positions are as follows:—

Star.	Magnitude.	Distance.	Position Angle.
		R	° ′
a	6·2	511·4	221 56
b	6·5	538·3	42 38
	Difference ...	26·9	179 18

The magnitudes are taken from the *Uranometria Argentina*. The star *a* is described as double in *Herschel's Results of Cape Observations*, the companion being called of the 11th magnitude, distant $1\frac{1}{2}''$; with the Heliometer no trace of this companion was ever detected. The screen used reduced *e Eridani* about two magnitudes, as the *Uranometria Argentina* gives for this star 4·4, and but little difference of brightness could ever be noted between the two stars under observation. The factor of parallax is also very favourable, being

$$+1{\cdot}970 \,.\, \mathrm{R} \,.\, \sin\,(\odot + 170^\circ 7)$$

for the *difference e Eridani-b – e Eridani-a.*

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For these comparison stars there are some older Meridian observations which show that their motions are but small, the following Table containing the Catalogue places brought up to 1882·0, simply by precession and without applying any systematic corrections :—

Authority.	1882·0.		No. of Obs.	
	R.A.	Decl.	R.A.	Decl.
	Star a.			
	h m s	° ′ ″		
Piazzi, 1800 ...	3 8 18·22	−44 51 39·3	5	5
Taylor, 1835 ...	16·97	44·6	3	3
Cape, 1840... ...	16·73	45·5	7	3
Cordoba, 1874* ...	17·08	46·5	7	7
Cape, 1880... ...	17·00	46·2	3	3
	Star b.			
	h m s	° ′ ″		
Piazzi, 1800 ...	3 21 58·38	−42 3 11·6	7	5
Taylor, 1835 ...	58·54	6·2	3	3
Cape, 1840... ...	58·70	3·0	2	3
Cordoba, 1876* ...	58·75	4·4	4	4
Cape, 1880... ...	58·68	5·5	3	3

* Communicated by Dr. Gould.

The proper motion used for *e Eridani* is

$$+0^{s}\cdot270 \text{ in R.A. and } +0''\cdot75 \text{ in Decl.}$$

agreeing closely with that derived by Mr. Stone.

The observations, in the usual form, now follow :—

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Observations.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	*e Eridani-a.*	*e Eridani-b.*
	1881.	h m				R	R
1	Mar. 16	8 27	1	2	58°0	511·396	538·318
2	22	8 49	3	2	53·1	·431	·339
3	April 1	8 58	3-4	4	54 8	·441	·369
4	2	8 47	1	2	54·3	·375	·282
5	June 20	23 18	2-3	3	55·3	·438	·311
6	24	23 23	2	2-3	49·8	·438	·304
7	28	23 4	2-3	3	50·3	·489	·387
8	July 3	22 47	2	3	46·4	·510	·386
9	8	23 3	3	3	46·2	·484	·379
10	Aug. 16	22 31	2	2-3	54·4	·363	·304 ¾ set
11	Sept. 22	22 54	2	3	60·2	·399	·276
12	25	23 18	1-2	2-3	54·5	·418	·348
13	Dec. 1	5 55	2	2	55·0	·394	·306
14	8	5 53	1-2	1-2	54·0	·388	·323
15	9	6 30	1-2	2	60·0	·432	·348
16	16	5 51	2-3	2-3	61·5	·419	·326
17	18	6 22	1-2	1-2	57·0	·381	·332
18	21	6 7	2	3-4	61·0	·398	·330
	1882.						
19	Jan. 18	7 17	2-3	3	65·0	·346	·274
20	19	6 44	2	2-3	61·0	·358	·303
21	Mar. 9	7 36	2	2-3	60·0	·351	·266
22	11	7 55	2-3	3-4	63·0	·414	·297
23	June 25	0 38	2-3	2-3	50·0	·572	·469
24	29	23 45	1-2	2	45·5	·507	·422
25	July 1	23 52	2	2-3	42·7	·368	·247
26	7	0 22	2-3	2	55·0	·350	·241
27	9	23 13	1-2	2	44·0	·393	·274

Projected on the lines joining *e Eridani* and the two stars we have for

	R
e Eridani-*a*	+0·1983
„ *b*	− ·1921

as the annual motions for the two distances.

The aberration corrections are, for

e Eridani-a	+0·0266 sin (⊙ +336°·3)
e Eridani-b	+ ·0285 sin (⊙ +332·9)

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The equations of condition follow, having been derived as hitherto from the *differences* correcting them by

$$-(\text{Observed } sum - 1049^{R}\cdot740)\frac{26\cdot9}{1049\cdot7}$$

and assuming the mean *difference*

$$26^{R}\cdot900+x$$

I may immediately state that I do not propose to include Observation No. 3 in the normals, or to use it for determining the parallax. It was one of the few carried out during the first few months of my work under abnormally bad circumstances of definition, and was condemned at the time of observation.

Equations of Condition.

No.					Residuals.
				R	R
1	$+1\cdot0x$	$+0\cdot224y$	$-0\cdot793z$	$=+0\cdot022$	$+0\cdot008$
2	1·0	+ ·124	− ·776	+ ·007	− ·005
3	1·0	− ·049	− ·749	+ ·026	[+ ·018]
4	1·0	− ·066	− ·746	+ ·011	+ ·003
5	1·0	−1·003	− ·529	− ·028	− ·016
6	1·0	−1·012	− ·518	− ·035	− ·023
7	1·0	−1·016	− ·507	− ·008	+ ·005
8	1·0	−1·016	− ·493	− ·030	− ·018
9	1·0	−1·008	− ·480	− ·010	+ ·002
10	1·0	−0·716	− ·373	+ ·044	+ ·050
11	1·0	− ·161	− ·272	− ·021	− ·027
12	1·0	− ·110	− ·264	+ ·028	+ ·021
13	1·0	+ ·859	− ·081	+ ·014	− ·013
14	1·0	+ ·910	− ·062	+ ·036	+ ·008
15	1·0	+ ·917	− ·059	+ ·014	− ·014
16	1·0	+ ·954	− ·040	+ ·006	− ·022
17	1·0	+ ·962	− ·034	+ ·052	+ ·023
18	1·0	+ ·971	− ·026	+ ·032	+ ·003
19	1·0	+ ·928	+ ·050	+ ·033	+ ·004

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Equations of Condition—continued.

No.		Residuals.
20	$+1{\cdot}0x + 0{\cdot}922y + 0{\cdot}053z = +0{\cdot}048$	$+0{\cdot}020$
21	$1{\cdot}0 + {\cdot}343 + {\cdot}187 + {\cdot}019$	$+ {\cdot}003$
22	$1{\cdot}0 + {\cdot}310 + {\cdot}193 - {\cdot}016$	$- {\cdot}032$
23	$1{\cdot}0 - 1{\cdot}013 + {\cdot}484 - {\cdot}015$	$- {\cdot}003$
24	$1{\cdot}0 - 1{\cdot}017 + {\cdot}495 + {\cdot}008$	$+ {\cdot}020$
25	$1{\cdot}0 - 1{\cdot}017 + {\cdot}500 - {\cdot}016$	$- {\cdot}004$
26	$1{\cdot}0 - 1{\cdot}011 + {\cdot}517 - {\cdot}003$	$+ {\cdot}009$
27	$1{\cdot}0 - 1{\cdot}016 + {\cdot}522 - {\cdot}016$	$- {\cdot}005$

The normals are, with equal weights and without No. 3,

$$\begin{array}{llll} +26{\cdot}00x & -2{\cdot}75y & -3{\cdot}05z & = {}^{R}+0{\cdot}176 \\ -2{\cdot}75 & +17{\cdot}98 & +0{\cdot}06 & +{\cdot}350 \quad [nn] = 0{\cdot}01722 \\ -3{\cdot}05 & +0{\cdot}06 & +4{\cdot}71 & -{\cdot}017 \end{array}$$

from which is formed

$$\begin{array}{llll} z = {}^{R}-0{\cdot}0020 & \pm {}^{R}0{\cdot}0061 & \text{or with } z = {}^{R}0 & \\ y \quad +{\cdot}0209 & {\cdot}0030 & y \quad +{\cdot}0209 & \pm 0{\cdot}0030 \\ x \quad +{\cdot}0087 & {\cdot}0025 & x \quad +{\cdot}0090 & {\cdot}0025 \end{array}$$

$$\pi = 0''{\cdot}136 \pm 0''{\cdot}020 \qquad \pi = 0''{\cdot}136 \pm 0''{\cdot}020$$

Probable error, 1 obs. $\pm 0{\cdot}165$ Probable error, 1 obs. $\pm 0{\cdot}164$

The residuals of the latter solution, without z, are found beside the equations of condition. I have grouped them as follows :—

	Prob. error, 1 obs.
I. 1–2, S. 1–2; I. 1–2, S. 2; I. 2, S. 2; I. 1–2, S. 2–3;	9 obs. $\pm 0''{\cdot}136$
I. 2, S. 2–3; I. 2, S. 3; I. 2–3, S. 2; I. 2–3, S. 2–3;	10 „ ·208
I. 2, S. 3–4; I. 2–3, S. 3; I. 2–3, S. 3–4; I. 3, S. 3;	7 „ ·128

There is, however, one observation, No. 10, which leaves a large residual; without it the second group gives a probable error of $0''{\cdot}154$, so that but

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little effect of definition may be inferred from the measures, and the above solution may stand. This last-mentioned observation, No. 10, consists of but twelve bisections, the last quarter set having been rejected on account of the Index Error having unaccountably changed between it and the previous bisections. Perhaps under these circumstances it would be as well to reject the observation entirely. This would give for the value of the unknowns

$$\begin{array}{lll} & \text{R} & \text{R} \\ z = & +0\cdot0053 & \pm 0\cdot0050 \\ y & +\ \cdot0228 & \cdot0026 \\ x & +\ \cdot0077 & \cdot0022 \end{array}$$

$$\pi = 0''\cdot149 \pm 0''\cdot017$$

Probable error, 1 obs. $\pm$ 0·138

The residuals for this solution differ but slightly from those of the first one.

The question of possible systematic error appears to me to be answered similarly as in the case of ζ *Tucanæ*. There is no cause for suspicion of such error, and it is questionable whether any real result can be derived from the assumption of the existence of such error. Nevertheless, I will give the solution, assuming x to be different *East* and *West* of the Meridian, the observations falling very closely into two such groups. The normal for x has to be replaced by the following two:—

$$\begin{array}{llll} & & & \text{R} \\ +13\cdot00x_{\text{E}} & -11\cdot10y & -0\cdot92z = & -0\cdot102 \\ +13\cdot00x_{\text{W}} & +\ 8\cdot35 & -2\cdot13 & +0\cdot278 \end{array}$$

and the complete solution gives

$$\begin{array}{lll} & \text{R} & \text{R} \\ z = & +0\cdot0012 & \pm 0\cdot0064 \\ y & +\ \cdot0265 & \cdot0074 \\ x_{\text{W}} & +\ \cdot0046 & \cdot0063 \\ x_{\text{E}} & +\ \cdot0148 & \cdot0077 \end{array}$$

$$\pi = 0''\cdot173 \pm 0''\cdot048$$

Probable error, 1 obs. $\pm$ 0·169

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Leaving out No. 10 leads to the following results:—

	R	R
z	$= +0{\cdot}0052$	$\pm\ 0{\cdot}0055$
y	$+\ {\cdot}0235$	${\cdot}0057$
x_W	$+\ {\cdot}0072$	${\cdot}0053$
x_E	$+\ {\cdot}0084$	${\cdot}0067$

$$\pi = 0''{\cdot}154 \pm 0''{\cdot}038$$

Probable error, 1 obs. $\pm\ 0{\cdot}141$

What little evidence these solutions carry with them may be taken, I think, to confirm the *à priori* conclusion of the freedom of the series from systematic error, and I consequently adopt as the result of my *e Eridani* work the value of the relative parallax from the first solution—viz.:—

$$\mathbf{0''{\cdot}14 \pm 0''{\cdot}02}$$

§ 14. *Parallax of Canopus.* ELKIN.

The comparison stars selected for *Canopus* (after *Sirius* the brightest star in the heavens) were situated nearer the principal star than any of our other pairs, but neither was the arrangement of the three stars a very symmetrical one, nor was the brightness of the comparison stars sufficient for the highest degree of accurate measurement. The approximate relative positions were—

Star.	Magnitude.	Distance.	Pos. Angle.
		R	° ′
a	8	107·6	293 59
b	$8\frac{1}{4}$	92·8	81 30
	Difference ...	14·8	192 29

As seen through the screen (the same as employed for *Sirius*) *Canopus* appeared about of the magnitude $7\frac{3}{4}$. The observations which follow consist nearly entirely of such made near the epochs of maximum parallax. They are corrected for aberration, using the formulæ—

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R
Canopus-a ... ... $+0''.0026 \sin(\odot - 101^\circ.7)$
Canopus-b ... ... $+0''.0023 \sin(\odot - 104^\circ.7)$

No correction for proper motion has been applied; the annual motions of *Canopus* are, according to STONE, zero in both co-ordinates.

Observations.

No.	Date.	Sidereal Time.	Images.	Steadiness.	Temperature.	*Canopus-a.*	*Canopus-b.*
	1881.	h m			°	R	R
1	Mar. 17	11 18	2-3	2-3	60.4	107.612	92.750
2	19	11 56	1	2	59.7	.598	.758
3	April 9	10 54	2	2	58.2	.641	.740
4	22	10 11	1-2	2	60.6	.651	.786
5	June 21	12 34	3	3	60.2	.542	.810
6	July 8	0 32	3	3	43.8	.560	.748
7	Aug. 30	2 25	1-2	1-2	56.0	.563	.764
8	Sept. 13	2 51	1-2	2	43.7	.571	.777
9	21	3 12	3	2-3	53.2	.579	.723
10	28	3 40	2-3	2-3	56.0	.602	.729
11	Oct. 4	2 14	2	2-3	57.0	.584	.717
12	8	2 9	1-2	2	55.0	.575	.761
	1882.						
13	Mar. 8	9 4	2	2	58.0	.597	.788
14	23	11 7	2-3	3	64.5	.586	.795
15	24	10 39	2	2-3	59.0	.615	.784
16	31	11 42	2	2-3	64.0	.595	.753
17	April 1	11 18	2	2	62.5	.580	.785 ½ set
18	Sept. 1	0 39	2	2-3	43.0	.579	.734
19	Nov. 6	2 1	2	2-3	48.5	.587	.764
20	7	1 27	2-3	2	57.0	.576	.766
21	10	2 14	2	2	58.0	.578	.758
	1883.						
22	Mar. 24	11 48	2-3	2-3	61.0	.572	.757
23	April 30	11 42	2-3	2-3	55.0	.585	.777
24	May 1	11 40	2-3	2-3	59.5	.608	.771
25	3	10 21	2	2	60.0	.600	.789

The equations of condition are deduced as usual, the coefficient of parallax being given by—

$$+1''.986 \text{ R} \sin(\odot + 267^\circ.3)$$

for the difference *Canopus-c*—*Canopus-b*, y is taken, $1''.986\ \pi$.

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The absolute term is formed by assuming for the mean difference—

$$^{R}14{\cdot}820,$$

and correcting the observed differences by—

$$-\frac{^{R}14{\cdot}82}{200{\cdot}35}\,(\text{Observed sum}-^{R}200{\cdot}35).$$

Equations of Condition.

No.					Residuals.	
					I.	II.
				R	R	R
1	$+1{\cdot}0x$	$-0{\cdot}992y$	$-0{\cdot}790z$	$=+0{\cdot}041$	$+0{\cdot}025$	—
2	1·0	− ·996	− ·784	+ ·020	+ ·004	—
3	1·0	− ·957	− ·729	+ ·079	+ ·063	—
4	1·0	− ·870	− ·691	+ ·039	+ ·024	—
5	1·0	− ·038	− ·527	− ·088	− ·102	—
6	1·0	+ ·246	− ·480	− ·005	− ·018	—
7	1·0	+ ·913	− ·335	− ·019	− ·027	−0·030
8	1·0	+ ·984	− ·297	− ·026	− ·038	− ·040
9	1·0	+1·001	− ·275	+ ·040	+ ·029	+ ·026
10	1·0	+1·000	− ·255	+ ·055	+ ·044	+ ·041
11	1·0	+0·988	− ·239	+ ·051	+ ·040	+ ·037
12	1·0	+ ·973	− ·229	− ·005	− ·016	− ·019
13	1·0	− ·961	+ ·184	− ·013	− ·018	− ·006
14	1·0	− ·997	+ ·226	− ·031	− ·036	− ·024
15	1·0	− ·998	+ ·228	+ ·008	+ ·003	+ ·015
16	1·0	− ·989	+ ·247	+ ·022	+ ·017	+ ·029
17	1·0	− ·986	+ ·250	− ·026	− ·031	− ·019
18	1·0	+ ·926	+ ·671	+ ·028	+ ·027	+ ·025
19	1·0	+ ·736	+ ·851	+ ·005	+ ·006	− ·005
20	1·0	+ ·724	+ ·854	− ·009	− ·008	− ·019
21	1·0	+ ·687	+ ·862	+ ·001	+ ·002	− ·009
22	1·0	− ·998	+1·228	− ·003	+ ·003	+ ·005
23	1·0	− ·795	+1·330	− ·013	− ·006	− ·007
24	1·0	− ·785	+1·333	+ ·015	+ ·022	+ ·021
25	1·0	− ·764	+1·338	− ·012	− ·005	− ·006

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With equal weights for all observations the normals are found—

$$\begin{array}{rrrrl} +25{\cdot}00x & -2{\cdot}95y & +3{\cdot}97z & = +0{\cdot}153^{R} & \\ -2{\cdot}95 & +19{\cdot}52 & -1{\cdot}83 & +{\cdot}004 & [nn] = 0{\cdot}0297 \\ +3{\cdot}97 & -1{\cdot}83 & +12{\cdot}96 & -{\cdot}114 & \end{array}$$

which give—

$$\begin{array}{lrr} & z = -0{\cdot}0111^{R} & \pm 0{\cdot}0066^{R} \\ y & +{\cdot}0004 & {\cdot}0054 \\ x & +{\cdot}0079 & {\cdot}0048 \end{array}$$

$$\pi = 0''{\cdot}003 \pm 0''{\cdot}035$$

Probable error, 1 obs. $\pm$ 0·305

The residuals are found in Column I. They show that the observations are of inferior accuracy, but that, apparently, their quality has improved towards the end very considerably. I have, therefore, made a further solution in which I have given in the first group of six observations, each one the weight 0·4; in the second group of six observations, each one the weight 0·7; and the rest each the weight 1·0. From the residuals themselves a still greater rate of increase of accuracy would result. The normals then become—

$$\begin{array}{rrrrl} +19{\cdot}60x & -2{\cdot}55y & +6{\cdot}86z & = +0{\cdot}072^{R} & \\ -2{\cdot}55 & +15{\cdot}57 & -3{\cdot}02 & +{\cdot}075 & [p.nn] = 0{\cdot}0166 \\ +6{\cdot}86 & -3{\cdot}02 & +11{\cdot}17 & -{\cdot}056 & \end{array}$$

which lead to the values—

$$\begin{array}{lrr} & z = -0{\cdot}0081^{R} & \pm 0{\cdot}0061^{R} \\ y & +{\cdot}0044 & {\cdot}0046 \\ x & +{\cdot}0071 & {\cdot}0045 \end{array}$$

$$\pi = 0''{\cdot}028 \pm 0''{\cdot}030$$

Probable error, 1 obs. of weight 1 $\pm$ 0·228

which differ but little from the previous ones.

I will also communicate the results of a solution in which the six first observations are not taken into consideration, although there is no particular

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reason beyond their discordant nature for their rejection. This gives for the normals—

$$\begin{array}{rrrr} +19{\cdot}00x & +\ 0{\cdot}66y & +\ 7{\cdot}97z = & +^{R}0{\cdot}067 \\ +\ 0{\cdot}66 & +15{\cdot}81 & -\ 4{\cdot}60 & +\ {\cdot}172\ [nn] = 0{\cdot}0121 \\ +\ 7{\cdot}97 & -\ 4{\cdot}60 & +10{\cdot}21 & -\ {\cdot}030 \end{array}$$

and their solution—

$$\begin{array}{lll} & {}^{R} & {}^{R} \\ z = & -0{\cdot}0009 & \pm\ 0{\cdot}0073 \\ y & +\ {\cdot}0104 & {\cdot}0048 \\ x & +\ {\cdot}0036 & {\cdot}0049 \end{array}$$

$$\pi = 0''{\cdot}067 \pm 0''{\cdot}031$$

Probable error, 1 obs. $\pm$ 0·220

The residuals for this solution are those in Column II. It will be noticed that the large value for z depends on these six rejected observations. In every case but a small relative parallax is obtained.

With regard to the probability of systematic error having influenced this result, I do not think that this is very great. The differences in magnitude are no greater than in the case of my ϵ *Indi* stars, in which but little effect of systematic error could be found. At the same time, I regret that there are not observations intermediate between the parallax maxima, which would make a more exhaustive discussion possible. As it is, there remains nothing but to assume the freedom of the series from systematic error, and, as a final result, I would suggest that of the second solution—

$$\pi = 0''{\cdot}03 \pm 0''{\cdot}030$$

§ 15. *Summary and General Conclusions.*

Before collecting together our separate results we must first discuss the definitive value of the parallax of those stars which have been observed by both of us.

α Centauri.

For the parallax of this star we have four complete and independent investigations, depending on four different pairs of comparison stars, viz., those described in Sections 1, 2, 3, 4.

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The following are the results:—

		Magnitude of Comparison Stars.		Resulting Parallax.	Probable Error.	Adopted Weight.
		α	β			
GILL	§ 1 ...	7	7¼	0″·747	±0″·013	6
	§ 2 ...	8	8	·760	·013 / ·021	2
ELKIN	§ 3 ...	7	7½	·783	·028	3
	§ 4 ...	8	8	·676	·027	1

Of these results Sections 1 and 3 depend on a very large number of observations—100 and 87—and the probable errors attached to the results include the introduction of terms into the equations of condition which we believe represent and eliminate every source of error that it is possible to conceive; we hold accordingly that these results are strictly reliable within such limits as are indicated by their probable errors. According to these errors their relative weights are as 4·6 : 1; but as different comparison stars have been employed, and as there is always a possibility of minute difference in the absolute parallaxes of the comparison stars, we have given these results weights of 6 and 3 respectively.

If the result of Section 2 can be assumed free from any systematic error depending on the hour angle of observation (an assumption that is supported not only by the internal evidence of the series, but by the collateral evidence of GILL's investigation of the parallax of *Sirius*, ε *Indi*, and *Lacaille* 9352), then the weight of this series is equal to that of Section 1. On the other hand, if the freedom of the series from systematic error is held to depend entirely upon the evidence furnished by the discussion of the series itself, without taking collateral evidence into account, the probable error of the parallax for this series is ±0″·021, and its theoretical weight is higher than that from Section 3. But considering that the freedom of the series from systematic error was proved only from observations made at the close of the series, it seems reasonable to allow this series a rather lower weight, and we have assigned to it weight 2.

To the results of § 4 we assign weight 1—a weight perhaps rather lower than it would otherwise receive, but from the fact that the investigation of

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systematic error (which is considerable) has been made at the end of the series instead of being distributed throughout it. With these weights the parallax of *α Centauri* becomes 0″·752, and we cannot be far wrong in writing it in round numbers—

$$\pi = 0''\cdot75 \pm 0''\cdot01$$

which is to be regarded as the parallax of that star relative to an average star of 7·6 magnitude.

Sirius.

For the parallax of *Sirius* we have the following results :—

	Magnitude of Comparison Stars.		Resulting Parallax.	Probable Error.	Adopted Weight.
	α	β			
§ 5. Gill	7	7	0″·370	± 0″·009	3
§ 6. Elkin, Series I.	7¾	8	·47	·022* / ·072†	¼
§ 6. „ „ II.	7¾	8	·39	·023	1

The observations of Section 5 seem to be entirely free from systematic error. There is reason *à priori* to suppose that no such error *can* exist, and the discussion of the observations shows the freedom of the series from such error.

Like remarks apply to the result of Section 6, Series 2. But the results of Section 6, Series 1, are undoubtedly liable to the suspicion of systematic error depending on the hour angle of observation, not only from the considerations pointed out by Elkin, but from the discordance of the results of the two series. The weight of this series, therefore, must not be estimated by the smaller value of its probable error, which assumes the non-existence of the systematic errors in question, but by the larger figure which takes them into account. If we give to the result from Section 6, Series 2, weight=*unity*, the theoretical weight for the result from Section 5 is 6·5, and that from Section 6, Series 1, is 0·10. We have, however, modified these weights, and

* Excluding systematic errors. † Including systematic errors.

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have assigned weights 3, $\frac{1}{4}$, and 1 as given in the preceding Table. The mean result, having regard to these weights, is $0''\cdot381$, and we do not over-estimate the accuracy of this result if we put its probable error at $+0''\cdot01$. We have, therefore, for the parallax of *Sirius* relative to an average star of $7\frac{1}{2}$ magnitude,

$$\pi = 0''\cdot38 \pm 0''\cdot01.$$

ϵ *Indi.*

For the parallax of ϵ *Indi* we have the following results:—

	Magnitude of Comparison Stars.		No. of Obs.	Resulting Parallax.	Probable Error.
	α	β			
§ 7. GILL	$7\frac{1}{4}$	$7\frac{3}{4}$	58	$0''\cdot260$	$\pm 0''\cdot028$*
				·286	·012†
§ 8. ELKIN	7	$7\frac{1}{4}$	50	·170	·032*
				·124	·019†

The discordance of these results is very disappointing, and there is no hypothesis on which they can be reconciled unless we suppose that one or both of the comparison stars observed by ELKIN has sensible parallax. His observations, it must be admitted, do not point to any proper motion of the comparison stars which would give reasonable grounds—according to accepted ideas—for such an hypothesis.

The ultimate test must depend on further investigation of the parallax of ϵ *Indi* employing different stars of comparison, and this can only be efficiently done with a Heliometer of greater optical power capable of observing fainter stars. For the present we must content ourselves with the mean result of our separate discussions in which systematic error has been assumed to exist. The arithmetical mean of these results is $0''\cdot215$, and in consideration of the

* Including systematic errors. † Excluding systematic errors.

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somewhat smaller probable error of the result from Section 7 we adopt in round numbers—

$$\pi = 0''.22 \pm 0''.03,$$

for the parallax of ϵ *Indi* relative to an average star of $7\frac{1}{4}$ magnitude.

An almost identical result is obtained by considering the solutions excluding systematic error, and giving weights to the results approximately proportional to their theoretical weights, viz. :—

Gill ...	...	0".286,	Weight 2
Elkin	...	·124	„ 1
		0".232	

The conclusions as to the parallax of the other stars observed by only one of us are sufficiently stated in our separate papers. The following Table, therefore, contains our final results :—

		Parallax.	Probable. Error.	Mag. of Comp. Stars.
α Centauri	Gill & Elkin	+0".75	± 0".01	7·6
Sirius	„ „	+ ·38	·01	7·5
ϵ Indi	„ „	+ ·22	·03	$7\frac{1}{4}$
Lacaille 9352 ...	Gill	+ ·28	·02	7·6
o_2 Eridani	„	+ ·166	·018	6·4
β Centauri	„	− ·018	·019	7
ζ Tucanæ	Elkin	+ ·06	·019	$7\frac{1}{2}$
e Eridani	„	+ ·14	·020	6·4
Canopus	„	+ ·03	·030	8

It may be well now, before closing this paper, to summarise the results of experience we have gained during the progress of the preceding investigations, and to consider briefly the methods by which similar work could be most advantageously conducted in future.

The probable error of a single complete observation may be very accurately estimated from the following Table, which gives, at a glance, the probable error of a single complete observation in average conditions of definition as deduced from each of the preceding investigations.

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Star.	Magnitude of Comparison Stars.		Reduced mag. of principal star.	Approximate Distances in Arc.		Probable error of one "complete set" of measures on one night of the *difference* of the two distances.
	α	β		α	β	
GILL'S *Observations.*						
§ 1. α Centauri ...	7	7¼	7	38″30	30″60	± 0″·114
§ 2. „ ...	8	8	8¼	6010	5460	·111
§ 5. Sirius	7	7	7	3680	3630	·092
§ 7. ε Indi	7¼	7¾	7½	2130	2640	·105
§ 9. Lacaille 9352 ...	7·9	7·3	7·4	6830	4410	·152
§ 10. o_2 Eridani ...	6	6·7	6½	6270	6500	·132
ELKIN'S *Observations.*						
§ 3. α Centauri ...	7	7½	7	6230	4970	±0″·161
§ 4. „ ...	8	8	8¼	2940	2800	·176
§ 6. Sirius, Series I. ...	7¾	8	7	4950	5030	·244
„ „ Series II....	7¾	8	7⅞	4950	5030	·156
§ 8. ε Indi	7	7¼	7¼	5200	5920	·192
§ 12. ζ Tucanæ... ...	7½	7½	7½	5190	5060	·153
§ 13. ε Eridani	6·2	6·5	6¼	6570	6920	·155
§ 14. Canopus	8	8¼	7¾	1380	1190	·228

The probable error of GILL'S observations of *β Centauri* (§ 11) is not comparable with the above, as only one distance was measured, and that with only four bisections on each occasion. The probable error of one set of this kind was ±0″·094, but the distance measured is only 950″.

Thus with a Heliometer of only *four inches* aperture and a power of 175 diameters, the *difference* of two nearly equal and opposite distances is measured on one night with a probable error which, on the average, may be estimated at 0″·15 for a single "complete set" of observations.

This accuracy is so considerable, corresponding, as it must be remembered it does, to a determination of the relative position of the central star with

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the probable error of $\frac{1}{13}$th of a second of arc, that it is evident that the errors chiefly to be feared are those of a systematic character, such as we have taken into consideration in the preceding discussions.

Our experience suggests the following precautions which should be taken to eliminate such errors in future investigations:—

1. In all observations a reversing prism should be employed, placed (in the position of a sunshade) between the eye-piece and the observer's eye, and used in the manner already described, pp. 10 and 11 (and also Mem. R. A. S. vol. xlvi. p. 37), so as to eliminate all personality in observing which depends upon the angle which the direction of measurement makes with the vertical.

2. It is far better to distribute the observations amongst two or more fairly symmetrical pairs of comparison stars, situated in as widely different angles of position as the case admits of, than to devote the same number of observations to measures from one pair, however advantageously placed.

3. No amount of time or trouble should be spared to provide screens by which the image of the principal star is rendered exactly similar in magnitude with each comparison star. The new form of screen-holder introduced by Repsolds' in the Heliometer recently made by them for Yale College, New Haven, United States,* presents peculiar facilities for carrying a variety of screens which can be immediately interchanged by a handle at the eye-end. It would, however, be of the highest importance to have some means by which the amount of light transmitted by the segment of the object-glass which forms the image of the brighter star could be regulated *continuously* at pleasure. We have suggested such a plan to Messrs. Repsold, and await their opinion as to its mechanical possibility.

4. Means should be contrived for saving the considerable part of the observer's time which at present is lost in reading off the scales. A plan by which this may be accomplished is suggested at p. 255 of the undermentioned article in the *Encyclopædia Britannica*.

5. If it is desired to determine the parallax of a particular star with the highest possible accuracy, it is not an economical plan to follow the usual method of observing throughout the whole year; it is a far more powerful method to confine the observations for parallax determination to epochs near

* For a description of this instrument, see 9th edition of the *Encyclopædia Britannica*, vol. xvi. p. 252 (Article, "Micrometer").

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the maximum and minimum of parallax. All the observations should be made at one or other of two convenient hour angles,* of which one is East the other West of the Meridian, and thus it is easy to determine the systematic errors which may depend upon refraction (owing to difference of colour between the principal star and the comparison star), or to personal error (which should be eliminated by use of the prism), or to any unforeseen cause, by making observations on the *same*† night at *both* these hour angles, which can always be conveniently done about the time of year when the star culminates near midnight.

If, however, our recommendations 1, 2, and 3 have been carefully followed, we believe that special observations to determine systematic error need only be employed in a few cases to demonstrate the efficiency of the adopted precautions, and they would certainly be unnecessary in an extended research, when the object is to determine the mean parallax of stars of a particular magnitude relative to stars of another class of magnitude.‡

It appears to us that such is the kind of research that is now demanded in the present state of Astronomy.

The great Cosmical questions to be answered are *not so much what is the precise parallax of this or that particular star*, but :

1. What are the average parallaxes of those of the *first*, *second*, *third*, and *fourth* magnitude respectively, compared with those of lesser magnitude ?
2. What connection does there subsist between the parallax of a star and the amount and direction of its proper motion—or can it be proved that there is no such connection or relation ?

From such data we should probably be able to determine the law of

* In some instances it will be possible to observe with large positive as well as large negative parallax factors at the same hour angle, this is of course the most simple and favourable case.

† It is a mere figure of speech to say the "same night;" we merely mean about the same mean epoch.

‡ It is also worthy of note that if a Minor Planet is observed with a Heliometer on a number of nights, relative to variously distributed surrounding comparison stars, for the purpose of determining its diurnal parallax, and thence the mean solar parallax, the resulting solar parallax will be entirely free from systematic error, so far as observation is concerned, if reasonable care has been taken in symmetrical selection of the comparison stars.

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absorption of star light in space, and be provided with the facts at present wanting for determining with more precision the amount and direction of the motion of the Solar System in space. The practical method of carrying out such an investigation appears to be indicated by our past experience.

Let us suppose that to determine the parallax of a particular star, a pair of suitable comparison stars have been found situated (like those for *Lacaille* 9352) in the line of the major axis of the star's parallactic ellipse, so that the parallax factor is 2. If a single observation is made at a parallax maximum, and at four epochs thereafter six months apart, such observations would lead to the following equations :—

$$\begin{aligned}
x - 1{\cdot}00y + 2\pi &= n_1 \\
x - 0{\cdot}50 - 2\pi &\quad n_2 \\
x \quad {\cdot}00 + 2\pi &\quad n_3 \\
x + {\cdot}50 - 2\pi &\quad n_4 \\
x + 1{\cdot}00 + 2\pi &\quad n_5
\end{aligned}$$

where the coefficient of y is the number of years from the mean epoch of observation.

If these equations are solved by the method of least squares, π is obtained with a weight of 19·2, whence if the probable error of n_1 n_2 &c. is $\pm 0''{\cdot}15$, *and if the observations are not affected by systematic error*, the probable error of the resulting parallax is

$$\pm 0''{\cdot}034$$

so that if *two* observations are made at each of the five epochs in question (10 observations in all) the parallax of the star will be determined with a probable error of

$$\pm 0''{\cdot}024$$

which is practically sufficient for the purpose in question.

In the course of a long series of investigations for determining the parallaxes of a large number of different stars (which parallaxes are afterwards to be classified according to the magnitude and proper motion of the corresponding stars), the effect of systematic error in determining the parallax of any particular star is simply to increase the probable error of the determination of the average parallax of that group of stars, unless we can suppose

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the systematic errors of a number of observations of the same class to run in one direction. This could be the case only if the determinations were all made in similar conditions, but it would be impossible, even if one desired it, to arrange a number of Heliometer observations in which this would be the case. The comparison stars of each group must of necessity be selected at very different distances and position angles, and of different colours and magnitudes. Thus the maximum parallax effect will be measured sometimes towards the brighter, sometimes towards the fainter star, sometimes towards the redder, sometimes towards the bluer stars, sometimes in the hotter, sometimes in the colder season, and so on. Thus the employment of any precautions against systematic error beyond 1, 2, and 3 above mentioned will be quite unnecessary.

In conclusion we shall briefly consider whether such a scheme of research as that above suggested is one that can be realised in the immediate future, or one that can only be carried to completion by the accumulated labours of successive Astronomers.

To fix our ideas, it is not too much to assume that an energetic observer can obtain, without undue fatigue, 200 complete sets of observations per annum, especially if he is aided by the proposed time-saving contrivances. We have each, without such aid, made over 250 sets of such observations in a year, but such a strain could not be continued for a series of years.

With a greater optical power (a Heliometer of 7 inches aperture would be necessary to secure a sufficient selection of comparison stars) there is no doubt, from the results of our experience summarised in the present section, that the probable error of a single "complete set" of observations of the difference of two distances could be reduced to $\pm 0''\cdot 10$ or less, so that from 10 complete sets of observations distributed as above described, the parallax of a star may still be determined with a probable error of $\pm 0''\cdot 02$, even though some of the comparison stars may not be very favourably situated in respect of parallax factor.

According to Gould (*Uran. Arg.*, p. 348) there are in the Southern Hemisphere 16 stars brighter than 2·0 magnitude. This would be a convenient number of stars for each group.

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Let there be selected

	16 stars	mag. 0 to 1·9
	16 „	„ 2 to 2·9
	16 „	„ 3 to 3·9
	16 „	„ 4 to 4·9
	16 „	Remarkable for proper motion in addition to the determinations contained in the present work.
Total—	80	

This would provide for the determination of the average parallax of each group with a probable error of $\pm 0''{\cdot}005$.

We should thus have in all 80 stars, each to be observed ten times. We have thus to provide in all for 800 "complete sets" of observations, which, at the rate of 200 per annum, would occupy only four years. Allowing time for necessary intervals of rest there is no doubt that a single observer, endowed with the requisite enthusiasm, perseverance, health, and skill, would accomplish this work in five years.

A desirable control on these results would be furnished by employing two pairs of comparison stars for each of the bright stars, and doubling the number of the fainter stars. This plan would extend the duration of the work to ten years, but would give the results a finality that would well repay the labour. It is a great work that is urgently demanded in the present state of Sidereal Astronomy, and it is one that should be undertaken without hesitation or delay.

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Plate I.

The dotted lines represent the form of the parallactic ellipse for each star whose parallax has been investigated in the preceding papers.

These ellipses have been laid down from the following data :—

	Pos. Angle of Major Axis of Par. Ellipse.	Minor Axis of Par. Ellipse (Major Axis = 1)
	°	
α Centauri	115·2	0·676
Sirius	84·9	·637
ϵ Indi	63·1	·660
Lac. 9352	64·4	·461
o_2 Eridani	77·7	·461
β Centauri	119·0	·696
ζ Tucanæ	42·0	·845
e Eridani	64·6	·849
Canopus	81·8	·970

The reader must bear in mind that these ellipses, if drawn to scale, would be quite invisible to the naked eye. The maximum parallax factor for measures of distance from any star of comparison is, therefore, represented graphically, not by A B (fig. 5), but by A C, where C D is perpendicular to A C, and tangent to the ellipse.

The graphical construction of such figures has been found by us to afford great facilities in selecting stars of comparison.

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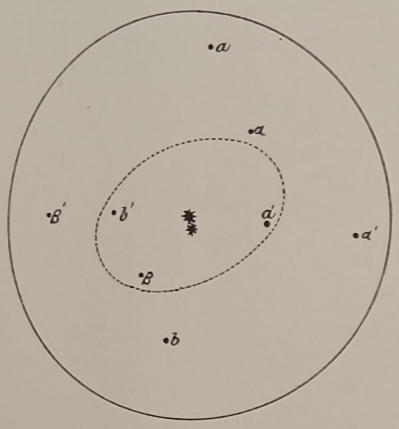
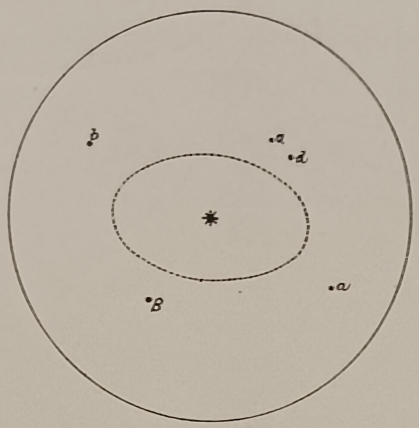
Fig. 1.



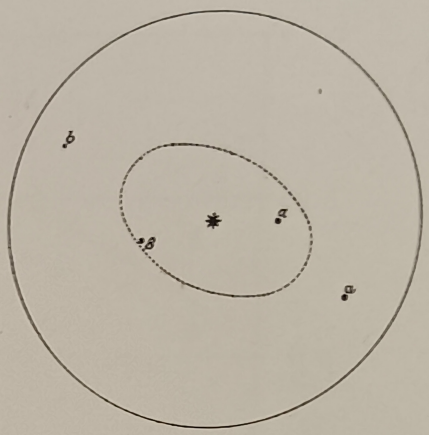
α Centauri

Fig. 2.



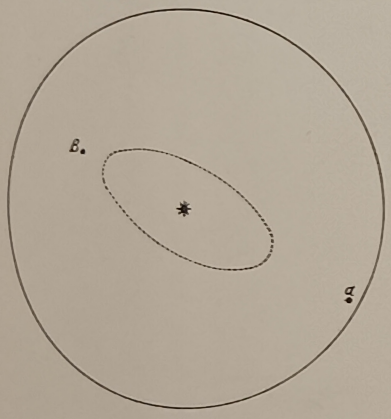
Sirius

Fig. 3.



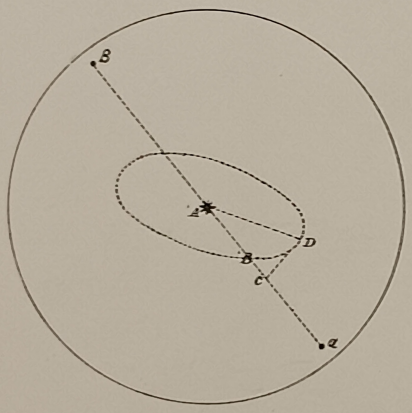
ε Indi.

Fig. 4.



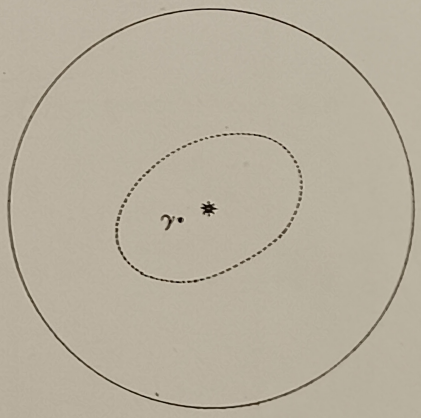
Lacaille 9352

Fig. 5.



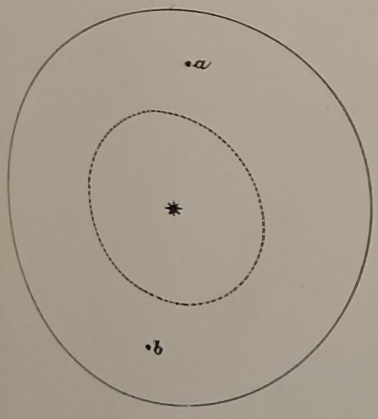
0_2 Eridani

Fig 6.



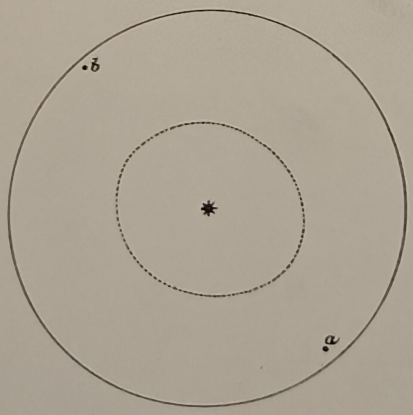
β Centauri.

Fig. 7



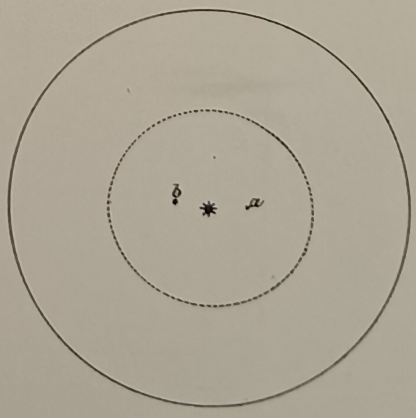
ζ Tucanae

Fig. 8.



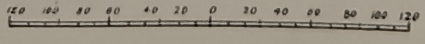
ε Eridani

Fig. 9.

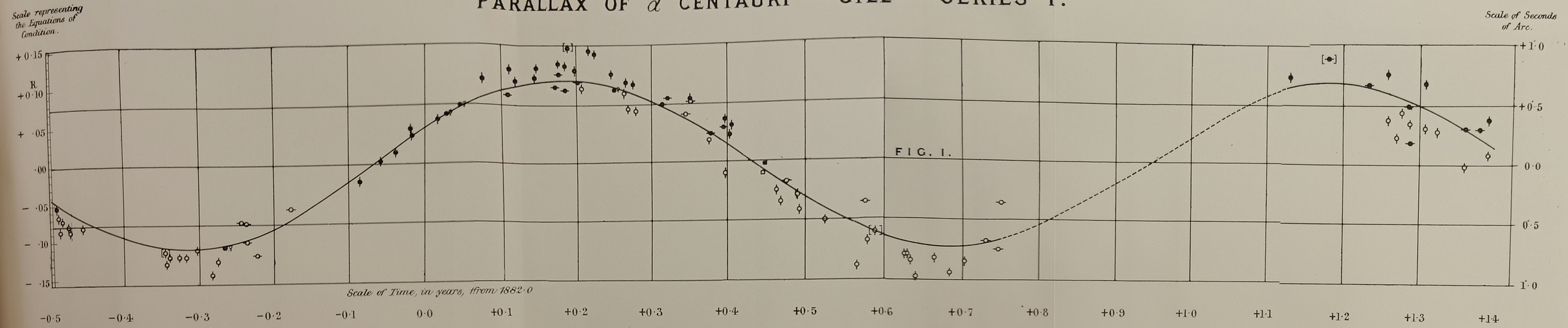


Canopus

Scale of minutes of arc



PARALLAX OF α CENTAURI — GILL — SERIES I.



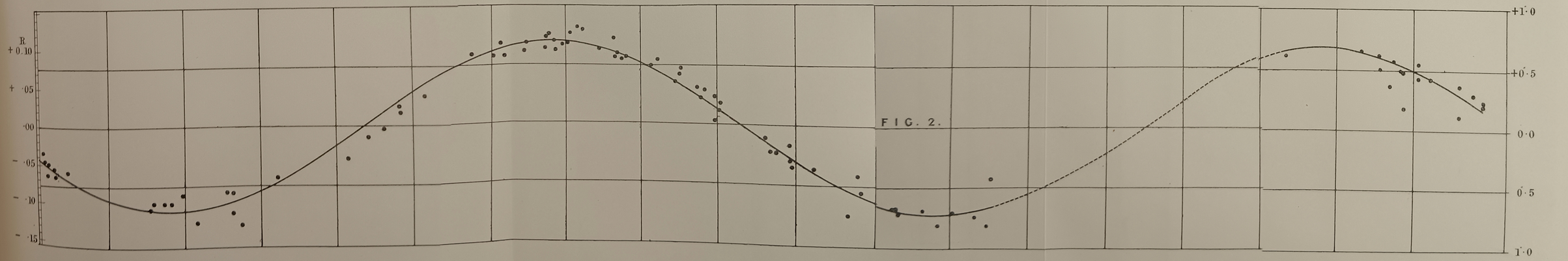


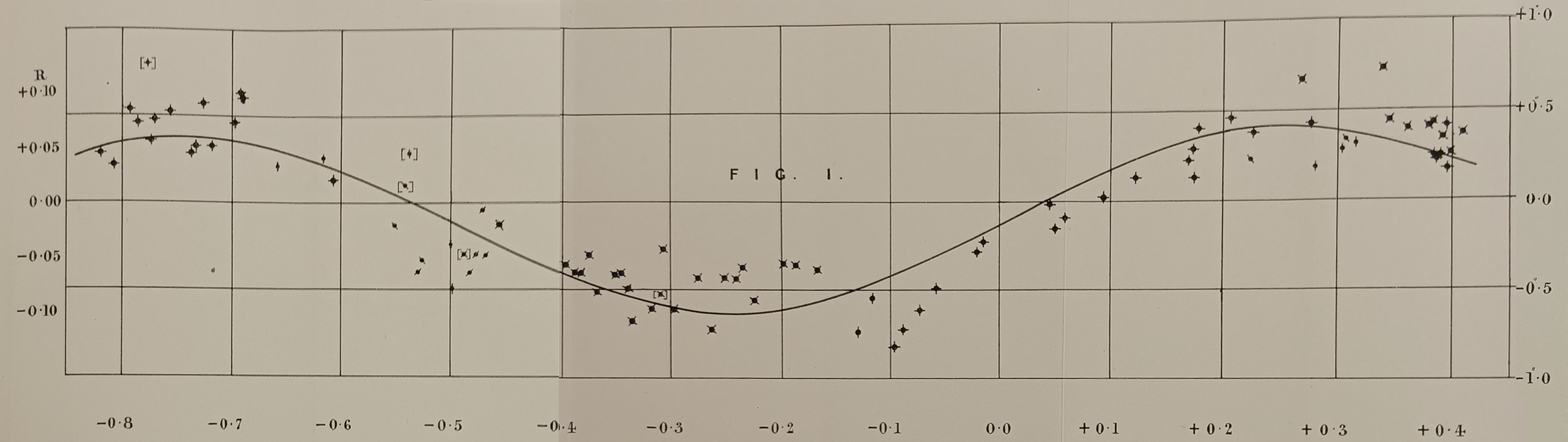
Fig. 1 *Shews the actual observations compared with the finally computed curve, but uncorrected for systematic errors of observation. The symbols* ♦ ● ◊ ○ *denote observations made in different directions relative to the line joining the observer's eyes, as explained in the text.*

Two observations, made with the reversing prism on June 13, 1882, *are marked* ▫ *and* ▪ *for the observation East and West of the Meridian respectively.*

Fig. 2 *Shews the same observations compared with the same curve, when the following corrections (determined in the text) have been applied.*

Observations marked	R	*Observations marked*	R
♦	− 0·018	◊	+ 0·021
●	± ·000	○	− ·009

PARALLAX OF α CENTAURI–ELKIN–SERIES I.



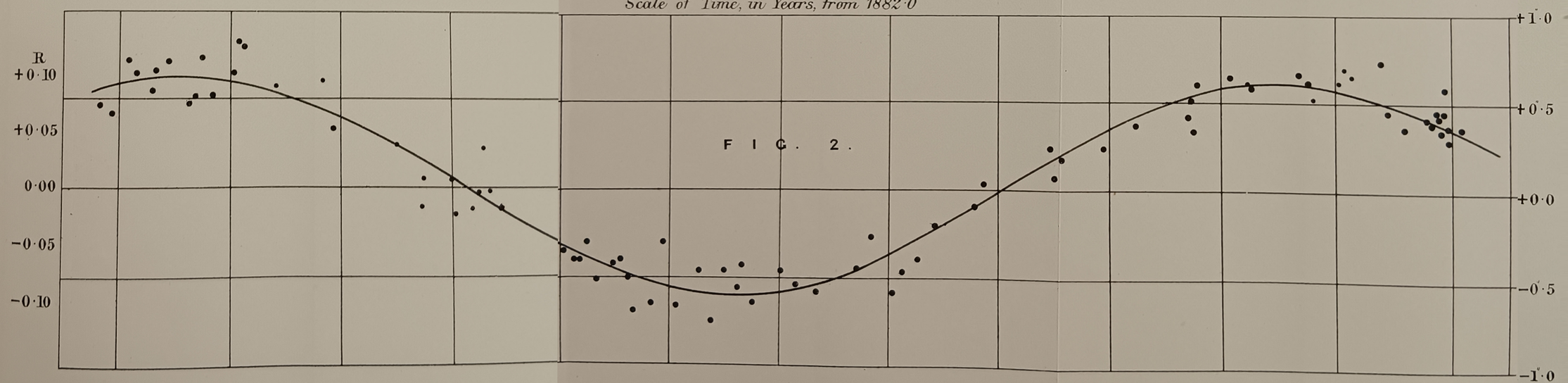
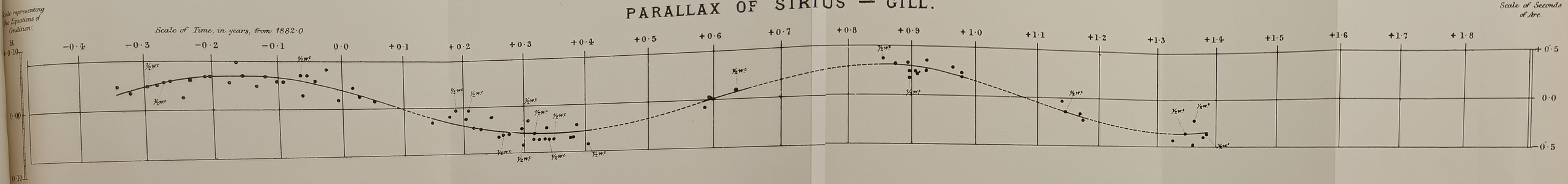
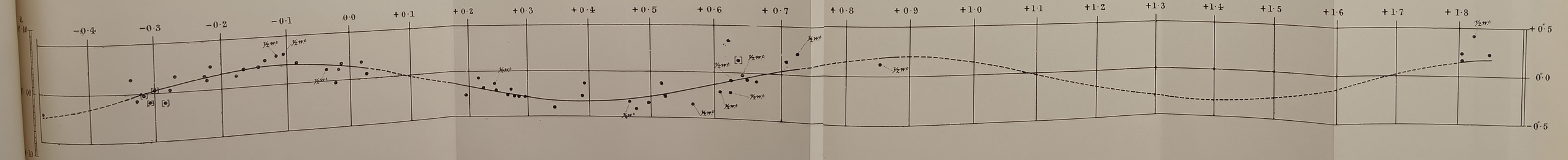


Fig. 1 *Shews the actual observations, as given by the absolute term of the equations of condition and the curve of the first incomplete solution. The symbols* ✦ ✖ ⁘ ⁘ ⁘ *denote the different positions of the observer's head relative to the line joining the stars, as explained in the text.*

Fig. 2 *Shews the same observations corrected for the systematic errors deduced in the text, and compared with the final solution curve. The smaller dots* (•) *are the observations not made use of in the final solution.*

PARALLAX OF SIRIUS — GILL.



PARALLAX OF ε INDI — GILL.